HEWLETT PACKARD

Hardware Reference Manual

HP 2250

Measurement and Control

HP 2250
Measurement and Control Processor
Hardware Reference Manual

HEWLETT
PACKARD

HEWLETT-PACKARD COMPANY
Roseville Division
8000 Foothills Boulevard
Roseville, California 95678

Update 3 (September 1982)
MANUAL PART NO. 02250-90001
Printed in U.S.A.
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PRINTING HISTORY

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Each reprinting of this manual will incorporate all past updates; however, no new information will be added. Thus, the reprinted copy will be identical in content to prior printings of the same edition with its user-inserted update information. New editions of this manual will contain new information, as well as all updates.

To determine what manual edition and update is compatible with your current software revision code, refer to the appropriate Software Numbering Catalog, Software Product Catalog, or Diagnostic Configurator Manual.

First Edition .... March 1981
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SAFETY CONSIDERATIONS

GENERAL - This product and relation documentation must be reviewed for familiarization with safety markings and instructions before operation.

SAFETY SYMBOLS

⚠ Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the product against damage.

Indicates hazardous voltages.

⏚ Indicates earth (ground) terminal (sometimes used in manual to indicate circuit common connected to grounded chassis).

WARNING **The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.**

CAUTION The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

CAUTION

STATIC SENSITIVE DEVICES

When any two materials make contact, their surfaces are crushed on the atomic level and electrons pass back and forth between the objects. On separation, one surface comes away with excess electrons (negatively charged) while the other is electron deficient (positively charged). The level of charge that is developed depends upon the type of material. Insulators can easily build up static charges in excess of 20,000 volts. A person working at a bench or walking across a floor can build up a charge of many thousands of volts. The amount of static voltage developed depends on the rate of generation of the charge and the capacitance of the body holding the charge. If the discharge happens to go through a semiconductor device and the transient current pulse is not effectively diverted by protection circuitry, the resulting current flow through the device can raise the temperature of internal junctions to their melting points. MOS structures are also susceptible to dielectric damage due to high fields. *The resulting damage can range from complete destruction to latent degradation.* Small geometry semiconductor devices are especially susceptible to damage by static discharge.

The basic concept of static protection for electronic components is the prevention of static build-up where possible and the quick removal of already existing charges. The means by which these charges are removed depend on whether the charged object is a conductor or an insulator. If the charged object is a conductor such as a metal tray or a person's body, grounding it will dissipate the charge. However, if the item to be discharged is an insulator such as a plastic box/tray or a person's clothing, ionized air must be used.

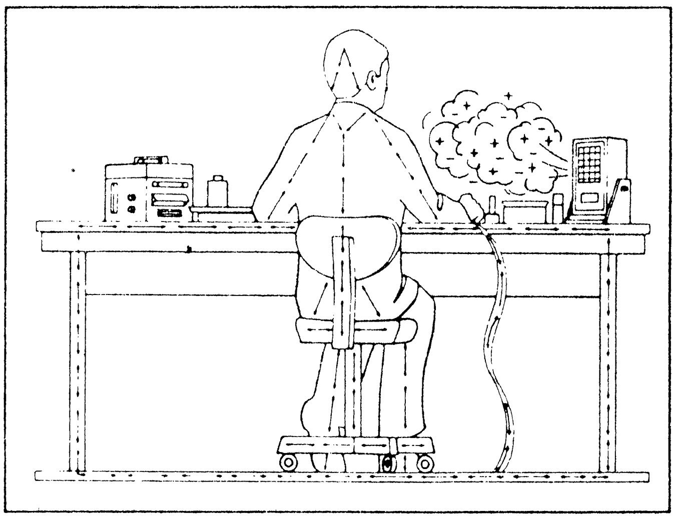
Effective anti-static systems must offer start-to-finish protection for the products that are intended to be protected. This means protection during initial production, in-plant transfer, packaging, shipment, unpacking and *ultimate use.* Methods and materials are in use today that provide this type of protection. The following procedures are recommended:

1. All semiconductor devices should be kept in "antistatic" plastic carriers. Made of transparent plastics coated with a special "antistatic" material which might wear off with excessive use, these inexpensive carriers are designed for short term service and should be discarded after a period of usage. *They should be checked periodically to see if they hold a static charge greater than 500 volts in which case they are rejected or recoated.* A 3M Model 703 static meter or equivalent can be used to measure static voltage, and if needed, carriers (and other non-conductive surfaces) can be recoated with "Staticide" (from Analytical Chemical Laboratory of Elk Grove Village, Ill.) to make them "antistatic."

2. Antistatic carriers holding finished devices are stored in transparent static shielding bags made by *3M Company*. Made of a special three-layer material (nickle/polyester/polyethylene) that is "antistatic" inside and highly conductive outside, they provide a Faraday cage-like shielding which protects devices inside. "Antistatic" carriers which contain semiconductor devices should be kept in these shielding bags during storage or in transit.

Individual devices should only be handled in a static safeguarded work station.

3. A typical static safeguarded work station is shown below including grounded conductive table top, wrist strap, and floor mat to discharge conductors as well as ionized air blowers to remove charge from nonconductors (clothes). Chairs should be metallic or made of conductive materials with a grounding strap or conductive rollers.



SAFETY EARTH GROUND - This is a safety class I product and is provided with a protective earthing terminal. An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the product must be made inoperative and be secured against any unintended operation.

BEFORE APPLYING POWER - Verify that the product is configured to match the available main power source per the input power configuration instructions provided in this manual.

If this product is to be energized via an auto-transformer (for voltage reduction) make sure the common terminal is connected to the earth terminal of the main power source.

SERVICING

WARNING

Any servicing, adjustment, maintenance, or repair of this product must be performed only by qualified personnel.

Adjustments described in this manual may be performed with power supplied to the product while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Capacitors inside this product may still be charged even when disconnected from its power source.

To avoid a fire hazard, only fuses with the required current rating and of the specified type (normal blow, time delay, etc.) are to be used for replacement.

WARNING

EYE HAZARD

Eye protection must be worn when removing or inserting integrated circuits held in place with retaining clips.

INPUT POWER DISTRIBUTION

HP 2250 Measurement & Control Systems are provided with a heavy duty on/off power switch. The power switch controls ac power for all devices in a single bay. Specifically, power is switched for the power supply and the cooling fans on the HP 2104 Processor Unit and HP 2251 Measurement & Control Unit.

An electrical ratings label is located on the outside of each cabinet that requires ac input power. HP 2250 systems do not have an integral circuit breaker. They should be connected to a circuit that has a breaker that exceeds the maximum amperage requirements of the system including all the cabinets.

NOTE

Input power wiring must be provided to the cabinet power switch box. This wiring should exceed both the voltage and current specified by the electrical ratings label. In addition, safety precautions require that the input power wiring be kept physically separated from any other wiring entering or inside the cabinet. The recommended method of meeting this requirement is by locating the input power wiring inside flexible conduit directly to the power switch box. All wiring should also meet the requirements specified by local electrical codes.

NOTE

All wiring installation and changes should be done with AC power off and only by a qualified electrician.

INPUT WIRING SPECIFICATIONS

The following specifications describe the ac power wiring:

Maximum voltage rating: 300 Volts AC

Maximum current carrying: 10 Amps

Maximum operating temperature: 65 degrees C

Maximum number of power cords per switch for power supplies and/or cooling fans: 4

Maximum number of cabinets powered by one power switch: 1

INPUT POWER WIRING

Refer to the wiring diagram attached to the power switch when using the following instructions. AC input power wiring should be attached to the cabinet as follows:

1) Remove the switch box cover by loosening the two screws.

2) Route the input wiring through the switch box knockout and clamp the flexible conduit or wiring so as to provide substantial strain relief to the wiring.

3) Attach spade lugs to the voltage, or "hot," neutral and ground lines.

4) The ground wire should be attached to the ground post inside the switch box. The ground post has a label with the ground symbol next to it. Loosen the two nuts on the ground post and place the ground lug from the input power wiring underneath the nuts. Retighten the two nuts securely.

5) The hot side of the switch is the side with the brown wire from the power supply cable. Attach the hot side of the input power wiring to the empty screw terminal on that side of the switch. Securely tighten the switch.

6) Attach the neutral side of the input power wiring to the empty screw terminal on the other side of the power switch. The other screw terminal on that side of the switch has a blue wire connected to it from the power supply. Securely tighten the screw terminal.

7) Being careful to not snag any wiring, replace the switch cover and tighten the two retaining screws.

8) Before applying ac power to the system, verify that the power supply and cooling fan voltage settings are correct for the voltage being applied.

ADDING ADDITIONAL POWER CORDS TO THE SYSTEM POWER SWITCH

When it is necessary to add additional power supplies or measurement & control units to the system, they may also be switched by the cabinet power switch. Refer to the wiring diagram while using the following instructions to add power cables to the switch:

1) Disconnect AC power at the circuit breaker or some point in the circuit prior to the 2250 system.

2) Remove the covers from the set screw connectors by twisting their cap while holding the wiring stationary. Loosen the set screw and remove the wiring.

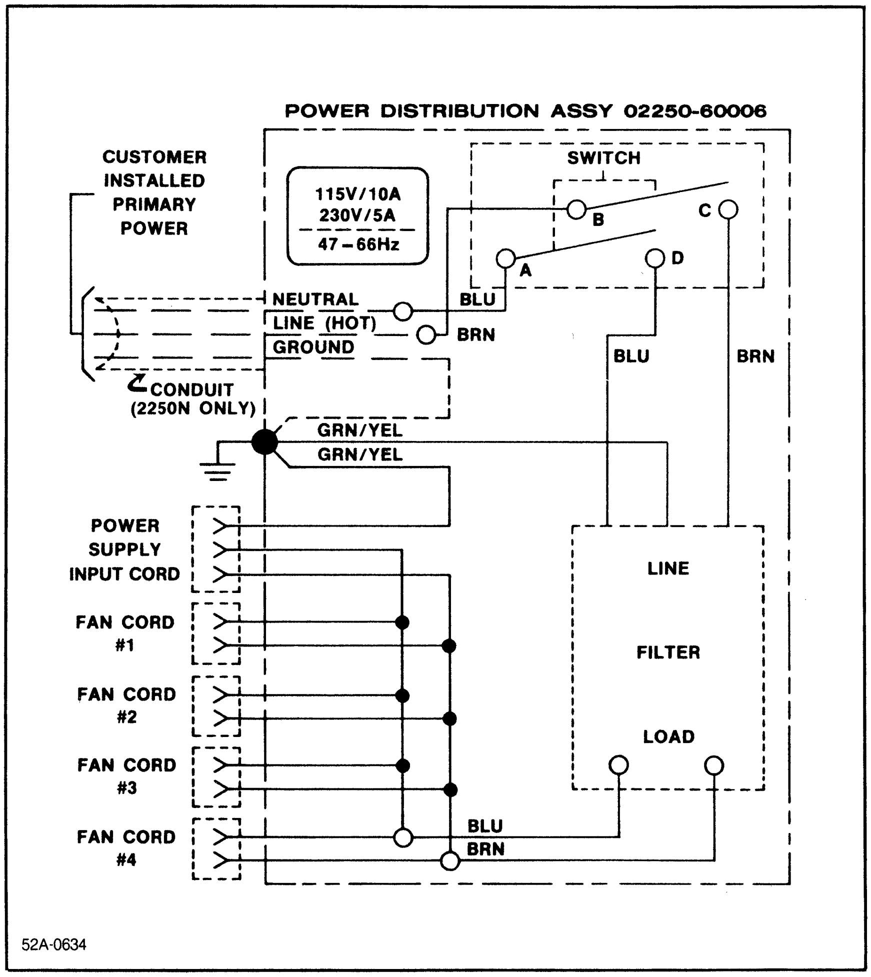
3) The fan cords have no polarity and therefore their cables can be arbitrarily added to the set screw connectors. The power supply cable has the following polarity — hot = brown, neutral = blue. Attach the brown wire to the bundle of cables that include the black wire to the switch. Add the blue wire to the bundle of cables that include the white wire to the switch.

4) Reinsert the wires into the metal sleeve and securely tighten the set screw. Reattach the plastic cap and tighten.

5) Being careful to not snag any wiring, replace the switch cover and tighten the two retaining screws.

6) Before applying the ac power to the system, verify that the power supply and cooling fan voltage settings are correct for the voltage being applied.

AC POWER WIRING



FEDERAL COMMUNICATIONS COMMISSION

RADIO FREQUENCY INTERFERENCE

STATEMENT

WARNING: This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. As temporarily permitted by regulation it has not been tested for compliance with the limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

PREFACE

This manual provides reference information for the Hewlett-Packard HP 2250 Measurement and Control Processor hardware.

The HP 2250 hardware consists of an HP 2104 Processor Unit and an HP 2251 Measurement and Control Unit, each of which consists of a card frame and several cards. Both units can be mounted in a rack or a cabinet, depending on the application.

DOCUMENTATION

Additional information for the HP 2250 is included in the following manuals:

a. HP 2250 Measurement and Control Processor Programmer's Manual, part no. 25580-90001.

b. HP 2250 Measurement and Control Processor System Introduction Manual, part no. 02250-90011.

c. HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part no. 02250-90012.

d. HP 25581A Automation Library Manual, part no. 25581-90001.

e. HP 25582A Automation Library for Desktop Computers, part no. 25582-90001.

f. HP 2250 Measurement and Control Processor Diagnostic and Verification Manual, part no. 25595-90001.

INTRODUCTION TO THE HP 2250

The HP 2250 Measurement and Control Processor is designed to provide computer controlled automation tasks including data acquisition, data reduction, engineering unit conversions, data comparisons for decision making, execution of control algorithms, control actions and updates, and alarm task scheduling.

When using the HP 2250 for data acquisition, you may do the following:

Detect discrete input signals such as the on or off state of a switch.

Measure continuously variable input signals such as temperature, pressure, speed, or voltage.

Set up discrete output signals such as the on or off state of an output relay.

Generate continuously variable output signals such as valve position or current.

ORGANIZATION OF THIS MANUAL

The HP 2250 hardware can be categorized into three main areas:

Racks and cabinets.

HP 2104 Processor Unit

HP 2251 Measurement and Control Unit

The HP 2251 can be further broken down into input/output, or "function" cards, which interface the HP 2250 Measurement and Control Processor to the external sensor or actuator that is being measured or controlled.

Information on each of these hardware areas is contained in a separate section of this manual, as follows:

Section I -- HP 2250 Measurement and Control Processor system description, consisting of an overall physical description including racks and cabinets, and an overall function description.

Section II -- HP 2104 Processor Unit

Section III -- HP 2251 Measurement and Control Unit

Section IV -- HP 25501A 16-Channel High-Speed Analog Input Card

Section V -- HP 25502A 32-Channel High-Level Multiplexer Card

Section VI -- HP 25503A 32-Channel Low-Level Multiplexer Card

Section VII -- HP 25504A 16-Channel Relay Multiplexer Card

Section VIII -- HP 25510A 4-Channel Voltage/Current Analog Output Card

Section IX -- HP 25511A 32-Point Digital Input Card

Section X -- HP 25513A 32-Point Digital Output Card

Section XI -- HP 25514A 16-Point Relay Output Card

Section XII -- HP 25516A 16-Point Digital Multifunction Card

Section XIII -- HP 25594A Thermocouple Reference Connector

Section XIV -- Signal Conditioning Modules

Two typical HP 2250 Measurement and Control Processors are shown in figure 1.

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Section XIII -- HP 25594A Thermocouple Reference Connector

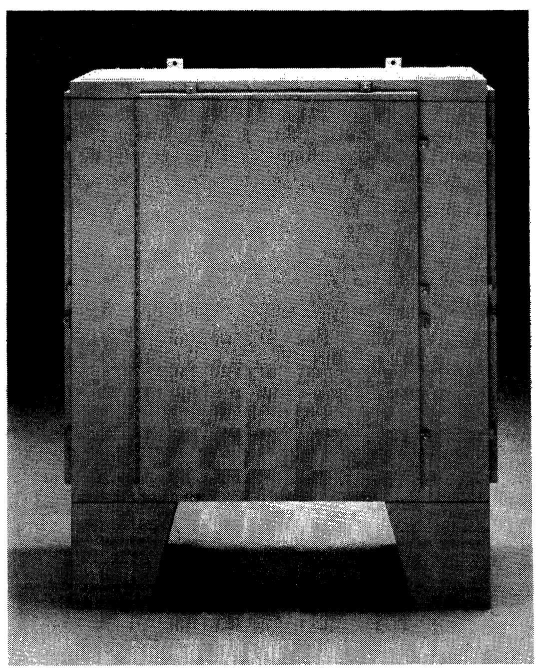
Section XIV -- Signal Conditioning Modules

Section XV -- HP 25512 4-Channel Counter Input Card

Section XVI -- HP 25515 4-Channel Pulse Output Card

Two typical HP 2250 Measurement and Control Processors are shown in figure 1.

HP-2250R
Rack-mounted for laboratory, control room, and light industrial applications.
It is shown here with an HP 1000 Model 45 Computer System.



HP 2250N
NEMA-12 sealed enclosure for factory floor application.

2250-1H

Figure 1. HP 2250 Measurement and Control Processors

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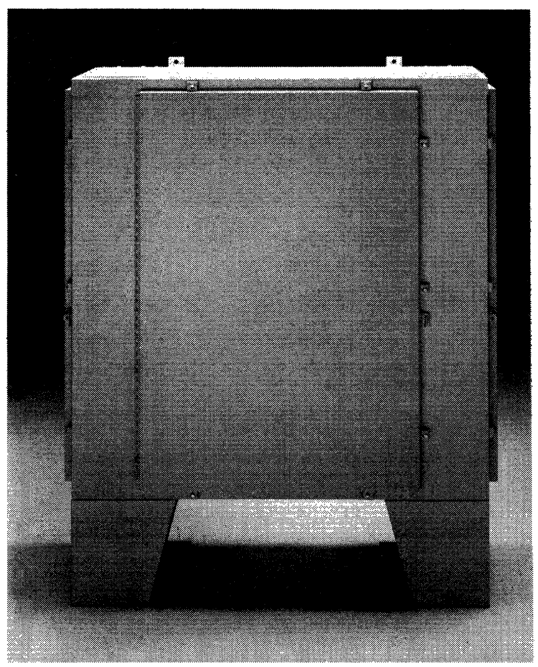
HP-2250R
Rack-mounted for laboratory, control room, and light industrial applications.
It is shown here with an HP 1000 Model 4-5 Computer System.



HP 2250N
NEMA-12 sealed enclosure for factory floor application.

2250-1H

Figure 1. HP 2250 Measurement and Control Processors

CONTENTS

Section I
HP 2250 System Description

1.1 INTRODUCTION

This chapter provides physical and functional descriptions of the HP 2250 Measurement and Control Processor. Included are photographs and diagrams showing the physical layouts of the various configurations of the HP 2250, and diagrams and a description of the functional operation of the system.

1.2 HP 2250 PHYSICAL DESCRIPTION

Figure 1-1 shows the components for the different configurations of the HP 2250. Digital and analog function cards perform I/O for the system. These function cards are part of the HP 2251AN/AR Measurement and Control Unit (MCU). Digital and analog signal conditioning modules are mounted on the function cards to tailor the function card for interfacing to the different types of external sensors and actuators. The HP 2104 Processor Unit consists of a card frame and several cards which control the operation of the HP 2250. Different combinations of the HP 2104 and HP 2251 comprise the several configurations of the HP 2250.

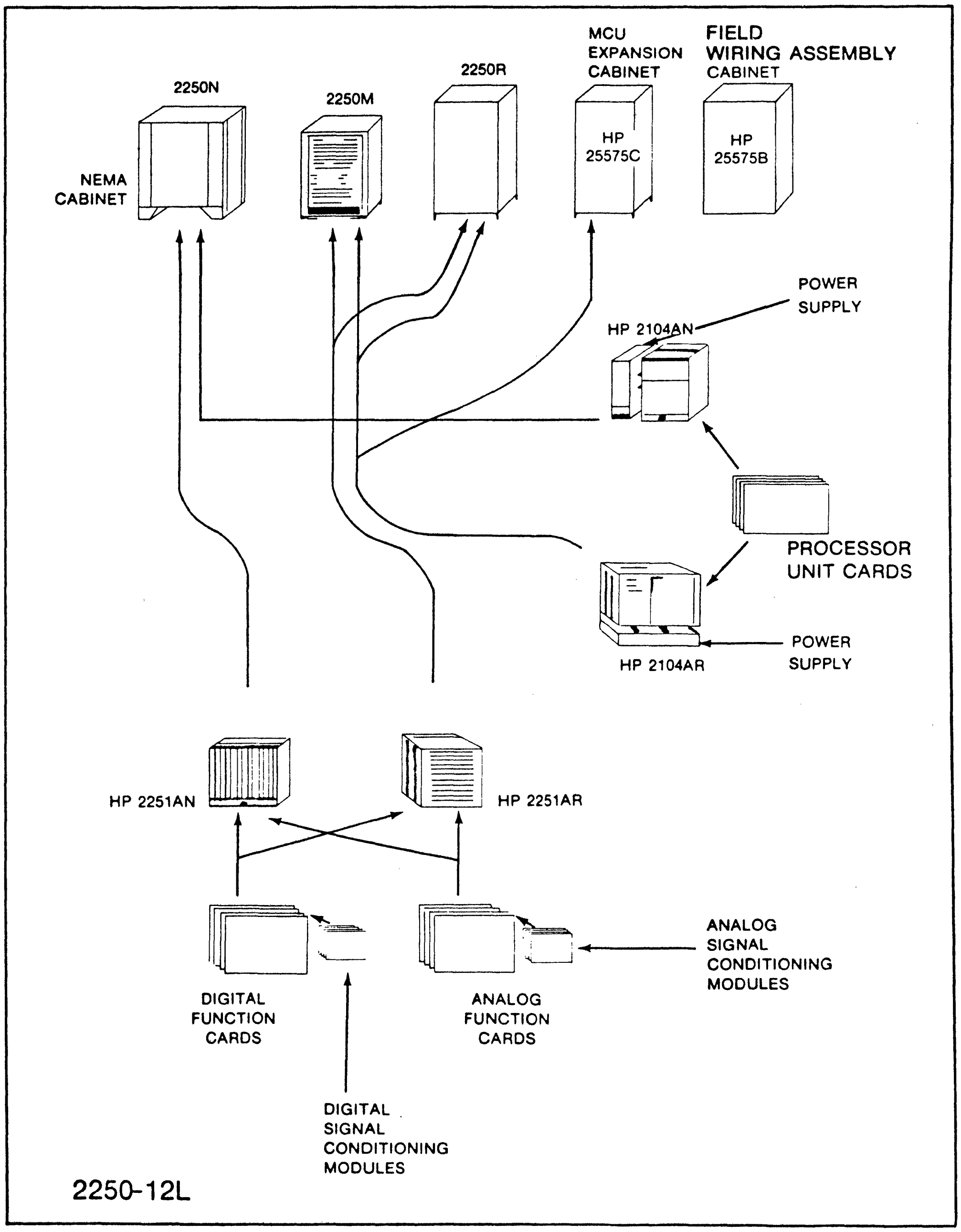


Figure 1-1. HP 2250 Measurement and Control Processor Components

The different configurations of the HP 2250 (shown in figure 1-2) are as follows:

HP 2250M Measurement and Control Processor

The HP 2250M is a complete measurement and control system in a small, mobile cabinet. The HP 2250M contains an HP 2104 Processor Unit, one HP 2251 Measurement and Control Unit, and provision for mounting up to ten field wiring assemblies (FWAs).

Options: -010 HP 12013A Battery Backup

-015 230 volt, 50 Hz operation

HP 2250N Measurement and Control Processor

The HP 2250N is a measurement and control processor in an industrial NEMA-12 cabinet. The HP 2250N contains an HP 2104 Processor Unit, nine additional card slots for adding an HP 2103LK Board Computer, up to two HP 2251 Measurement and Control Units (one required), and up to 40 field wiring assemblies (FWAs).

NOTE

NEMA stands for the National Electrical Manufacturer's Association, which defines standards for electrical equipment, including cabinets. A NEMA Type 12 cabinet, such as is used to house the HP 2250N, is defined as being moisture resistant, and dust resistant. In addition, the cabinet is designed to provide the necessary cooling surface for the heat from electronic components, up to 50 degrees C external temperature.

Options:

-010 HP 12013A Battery Backup

-015 230V, 50 Hz operation.

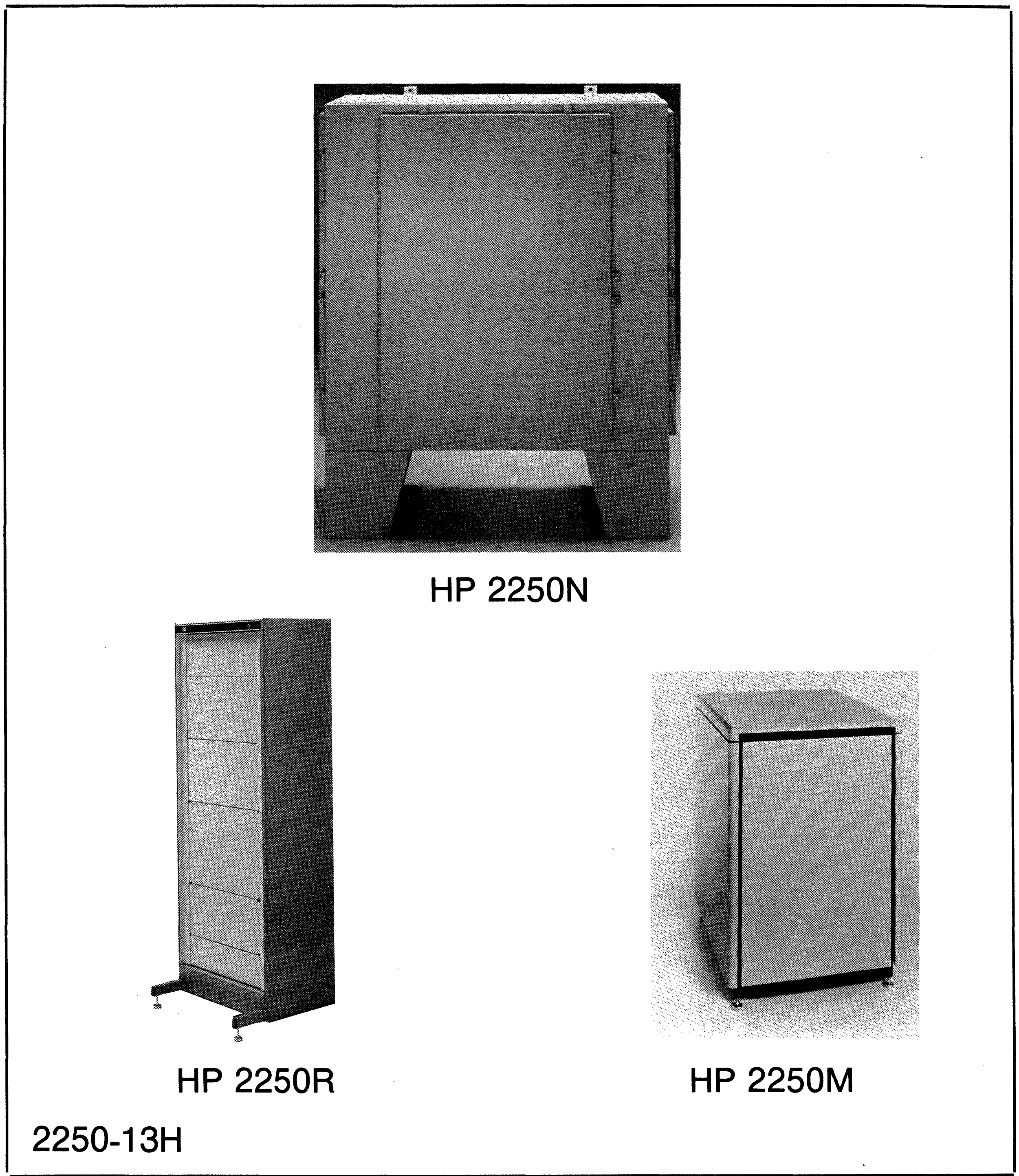


Figure 1-2. HP 2250 System Configurations

HP 2250R Measurement and Control Processor

The HP 2250R is a measurement and control processor in an upright, standard 19-inch cabinet. The HP 2250R contains an HP 2104 Processor Unit, and provision for two (one required) HP 2251 Measurement and Control Units, and up to 20 FWAs. This model can be expanded (using additional cabinets) to mount up to six more (eight total) HP 2251AR Measurement and Control Units (MCUs) and up to 175 more (195 total) FWAs.

Options:

-001 One additional HP 25575B cabinet with space for 45 FWAs.

Total capacity: Two MCUs, 16 function cards, 65 FWAs.

-002 Two additional HP 25575B cabinets, each with space for 45 FWAs.

One additional HP 25575C cabinet, with space for one power supply, three MCUs, and 20 FWAs.

Total capacity: Five MCUs, 40 function cards, 130 FWAs.

-003 Three additional HP 25575B cabinets, each with space for 45 FWAs.

Two additional HP 25575C cabinets, each with space for one power supply, three MCUs, and 20 FWAs.

Total capacity: Eight MCUs, 64 function cards, 195 FWAs.

-010 HP 12013A Battery Backup

-015 230 volt, 50 Hz operation

-016 Same as option -002, except with 230 volt, 50 Hz operation (option -015).

-017 Same as option -003, except with 230 volt, 50 Hz operation (option -015).

1.2.1 HP 2251AN/AR Measurement and Control Unit

There are two models of the HP 2251 Measurement and Control Unit (MCU):

HP 2251AN Measurement and Control Unit:

Designed for mounting in a NEMA enclosure, for use with the HP 2250N.

HP 2251AR Measurement and Control Unit:

Designed for rack mounting in cabinets, for use with the HP 2250M and HP 2250R.

The two models of the MCU are shown in Section III, figure 3-1. Each MCU consists of a function card frame and a backplane wiring assembly. The function card frame contains a Backplane Interface (BIF) card (part number 25574-60001) and room for up to eight function cards. The types of function cards available are:

HP 25501A 16-Channel High-Speed Analog Input
HP 25502A 32-Channel High-Level Multiplexer
HP 25503A 32-Channel Low-Level Multiplexer
HP 25504A 16-Channel Relay Multiplexer
HP 25510A 4-Channel Voltage/Current Analog Output
HP 25511A 32-Point Digital Input
HP 25513A 32-Point Digital Output
HP 25514A 16-Point Relay Output
HP 25516A 16-Point Digital Multifunction

Signal conditioning modules, which are small printed circuit assemblies, are mounted on the function cards in order to tailor the function card for interfacing to many types of actuators and sensors. The different types of signal conditioning modules (SCMs) are as follows:

HP 25531B/C/D/E/K/L One-Point Non-Isolated Strobe Digital Input
HP 25533B/C/D/E/F/G/H/J One-Point Isolated Strobe Digital Input
HP 25535B/C/D/E/K/L Four-Point Non-Isolated Digital Input
HP 25537P/Q/R/S/T/U/V/W Four-Point Isolated Digital Input
HP 25539A/B/G/H/I 4-Channel Relay Arc Suppression
HP 25540A/B/C/D 8-Channel Analog Input
HP 25543N Four-Channel Isolated Output
HP 25544A/B/C Four-Channel Non-Isolated Output
HP 25545P Two-Channel Solid State Relay Output

From one to eight MCUs are included in a HP 2250 system, depending on the configuration and application.

1.2.2 HP 2104AN/AR Processor Unit

The HP 2104 Processor Unit performs task processing, and data computation and conversion for the HP 2250 system. Briefly, it compiles and executes requests from the controller (host computer system), and converts measurement and control data resulting from these requests. See Section II for a complete description of the HP 2104 Processor Unit.

As with the MCU, the processor unit has two models:

HP 2104AN Processor Unit:

Designed for mounting in a NEMA enclosure, for use with the HP 2250N.

HP 2104AR Processor Unit:

Designed for rack mounting in cabinets, for use with the HP 2250M and HP 2250R.

The two models of the HP 2104 are shown in Section II, figure 2-1. Each unit consists of a card frame, a backplane wiring assembly, an HP 12035A Power Supply, and the following cards:

HP 12001D Processor
HP 12070B RAM/ROM/STACK (RRACK) Memory
HP 12071A Measurement and Control Interface (MCI)
HP 12009A HP-IB Interface

Optional cards for the processor unit are:

HP 12013A Battery Backup
HP 37203L HP-IB Modem

In addition, the customer may install an HP 37203L HP-IB modem for remote extension of an HP 2250 via either coax or fiber-optic cable.

1.3 HP 2250 FUNCTIONAL DESCRIPTION

A functional block diagram of the HP 2250 is shown in figure 1-3. As noted in the physical description paragraphs, the HP 2250 is composed of an HP 2104 Processor Unit, from one to eight HP 2251 Measurement and Control Units, and up to 64 I/O or function cards which send and receive measurement and control signals to external sensors and actuators. (The external sensors and actuators comprise a "process" such as the operation of a steel mill or an oil refinery.) The function cards are wired to the external process through Field Wiring Assemblies (FWAs); there can be up to 195 FWAs.

The HP 12001D Processor compiles and executes requests from the HP-IB bus and converts measurement and control data resulting from these requests.

The HP 12070A Memory contains Read Only Memory (ROM) chips, and Random Access Memory (RAM) chips. The HP 2250 firmware (MCL/50) is stored on the ROM chips. The RAM chips contain user memory, which is used to store instructions that implement a particular measurement and control function, and to store the data resulting from the instructions.

The HP 12071A Measurement and Control Interface (MCI) provides interface between the processor unit backplane and the measurement and control unit (MCU) backplane, a time-of-day clock, a pacing timer, and an external pace input. (The MCU backplane connects to the function cards which provide the input/output capability for measurement and control.)

The HP 12009A HP-IB Interface includes an HP-IB cable and carries control signals and data to and from the host computer (controller). UP to 14 other HP-IB devices also can be connected to this bus without remote extension via coax or fiber-optics.

The HP 12035A power supply provides the processor unit backplane with dc voltages and a 25 kHz voltage source to the MCUs via the backplane interface (BIF) card.

The HP 2251 Measurement and Control Unit (MCU) contains a card frame which holds the backplane interface card and room for up to eight function cards. There can be up to eight MCUs in an HP 2250 system.

The Backplane Interface (BIF) card provides the function cards with signal buffering, partial address decoding, interrupt masking, and 25 kHz power. In a system consisting of more than one MCU, each MCU contains one BIF card, and the MCI bus connects through each BIF to the succeeding (or "downstream") MCUs in a "daisy chain" fashion.

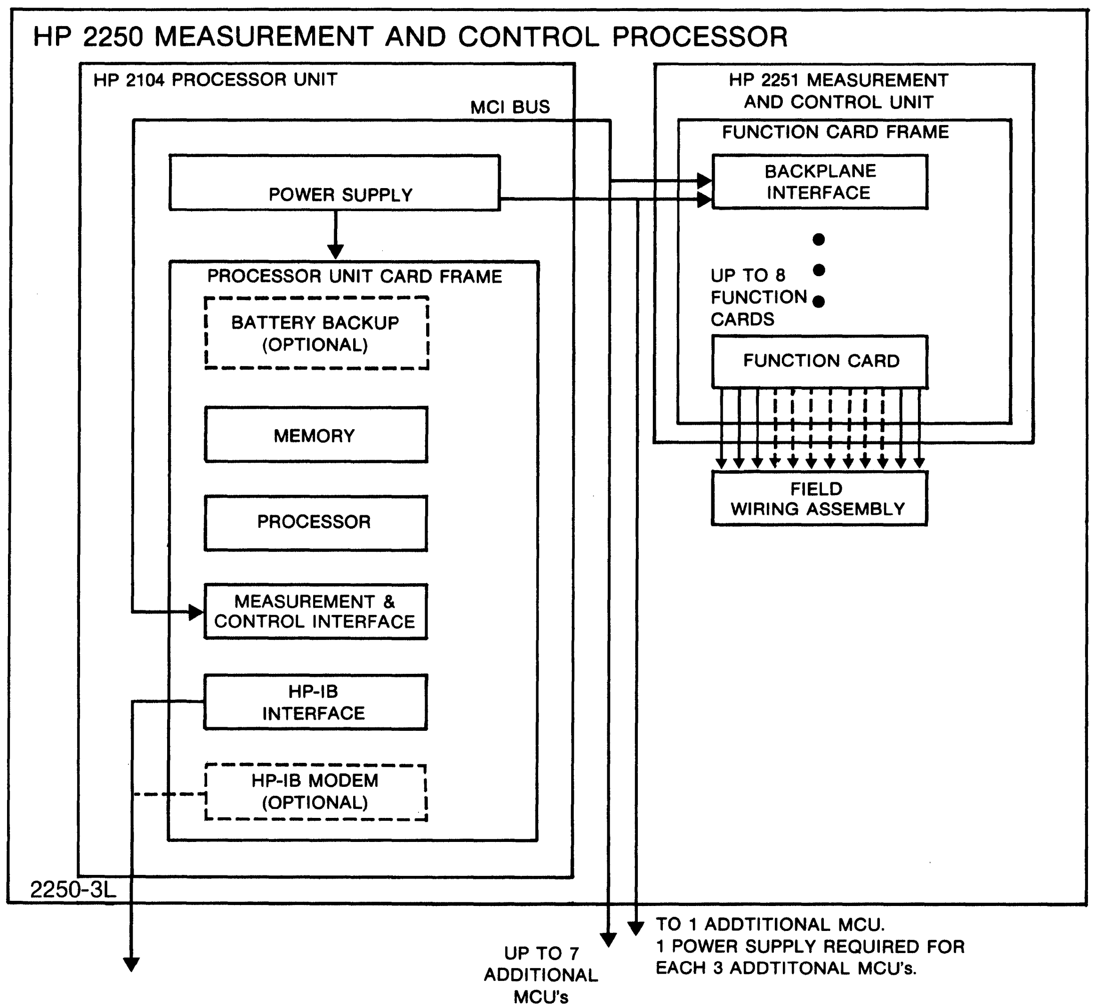


Figure 1-3. HP 2250 Functional Block Diagram

Function cards match the type of sensor or actuator in the external process. The principal function card types are analog input and output, and digital input and output.

A function card can accomodate up to 32 external points (depending on card type) and occupies one slot in the MCU card frame.

Section II
HP 2104 Processor Unit

2.1 INTRODUCTION

This section contains information on the HP 2104 Processor Unit. The processor unit, see figure 2-1, is the computing and control portion of the HP 2250 Measurement and Control Processor.

The basic processor unit cards are:

HP 12001D Processor

HP 12070A RAM/ROM/STACK (RRACK) Memory

HP 12071A Measurement and Control Interface (MCI)

HP 12009A HP-IB Interface

HP 12035A Power Supply

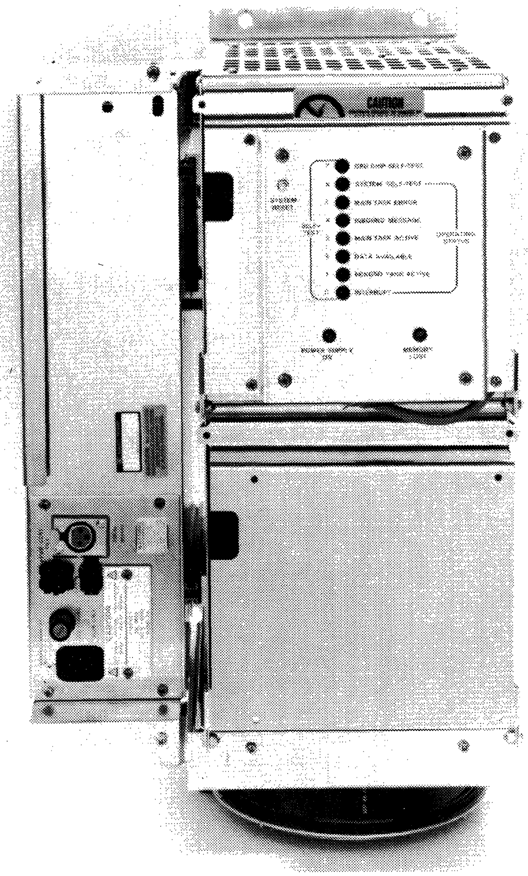
Optional cards for the processor unit are:

HP 12013A Battery Backup

HP 37203L HP-IB Modem

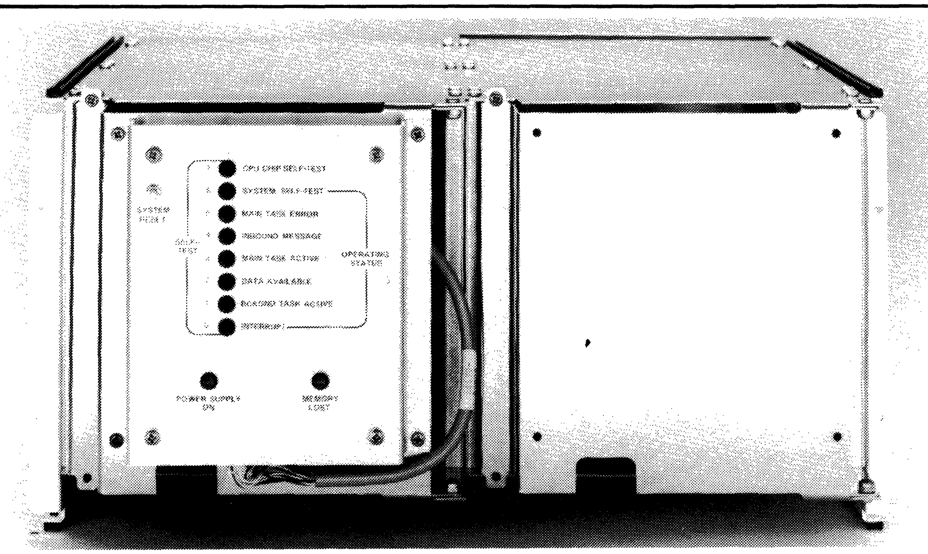
The processor unit cards are shown in figure 2-2.

The processor unit executes programmed instructions to provide control over the I/O (function) cards. The processor unit communicates with a host computer (controller) over the HP-IB interface, then compiles and executes requests, and reduces and converts measurement and control data resulting from these requests.



HP 2104AN

52A-0612



HP 2104AR

52A-0613

Figure 2-1. HP 2104AN and HP 2104AR Processor Units

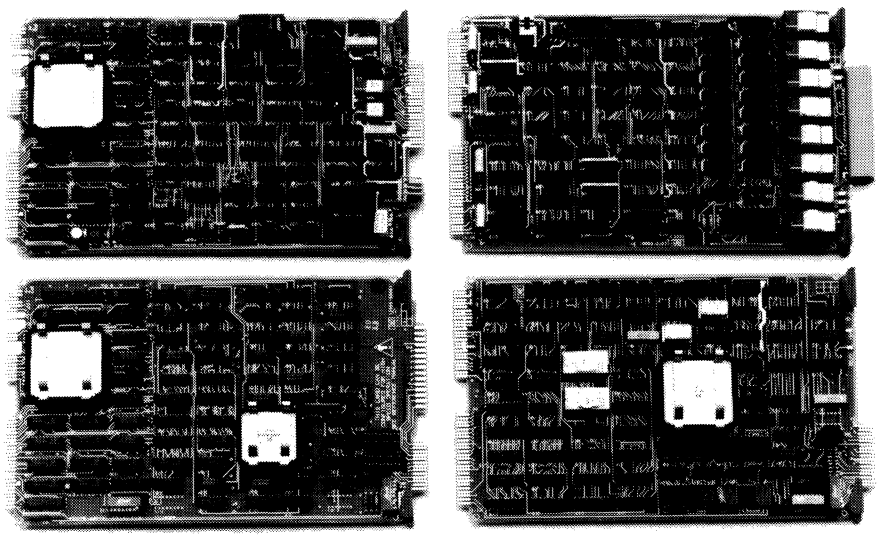


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Figure 2-2. HP 2104 Processor Unit Cards

The 12001D processor card communicates with the function cards through two levels: The first level is the 12071A measurement and control interface (MCI) which provides interface between the processor unit backplane and the measurement and control unit (MCU) backplane. (The MCU backplane connects to the I/O (function) cards which provide the input/output capability for measurement and control.) The second level is the backplane interface (BIF) card located in each MCU. The BIF card distributes measurement and control backplane signals to the individual function cards in the MCU over the function card backplane. The BIF selects one of the eight function cards to be addressed, provides data transfer ac voltage to the function card requirements.

The 12070A memory card contains Read Only Memory (ROM) chips, and Random Access Memory (RAM) chips. The HP 2250 firmware is stored in the ROM chips. The RAM chips are user memory, and are used to store instructions that implement a particular measurement and control process, and to store the data resulting from the instructions.

The 12071A measurement and control interface (MCI) card provides interfacing between the processor unit backplane and the measurement and control unit (MCU) backplane. The MCU backplane connects to the functions cards, which provide the input/output capability for measurement and control.

The 12009A HP-IB interface card includes a two-meter HP-IB cable which carries control signals and data to and from a host computer (controller). Up to 15 other HP-IB devices can be also be connected to the HP-IB.

The 12013A battery backup card protects memory contents up to 30 minutes if power fails.

The 37203L HP-IB link extends the transmission distance of the HP-IB bus to remote locations via coaxial cable or fiber optic (HP 37203L, Option 001) cable. The maximum distance is 1000 metres (3280 feet).

2.2 FUNCTIONAL DESCRIPTION

A functional block diagram of the HP 2104 Processor Unit is shown in figure 2-3.

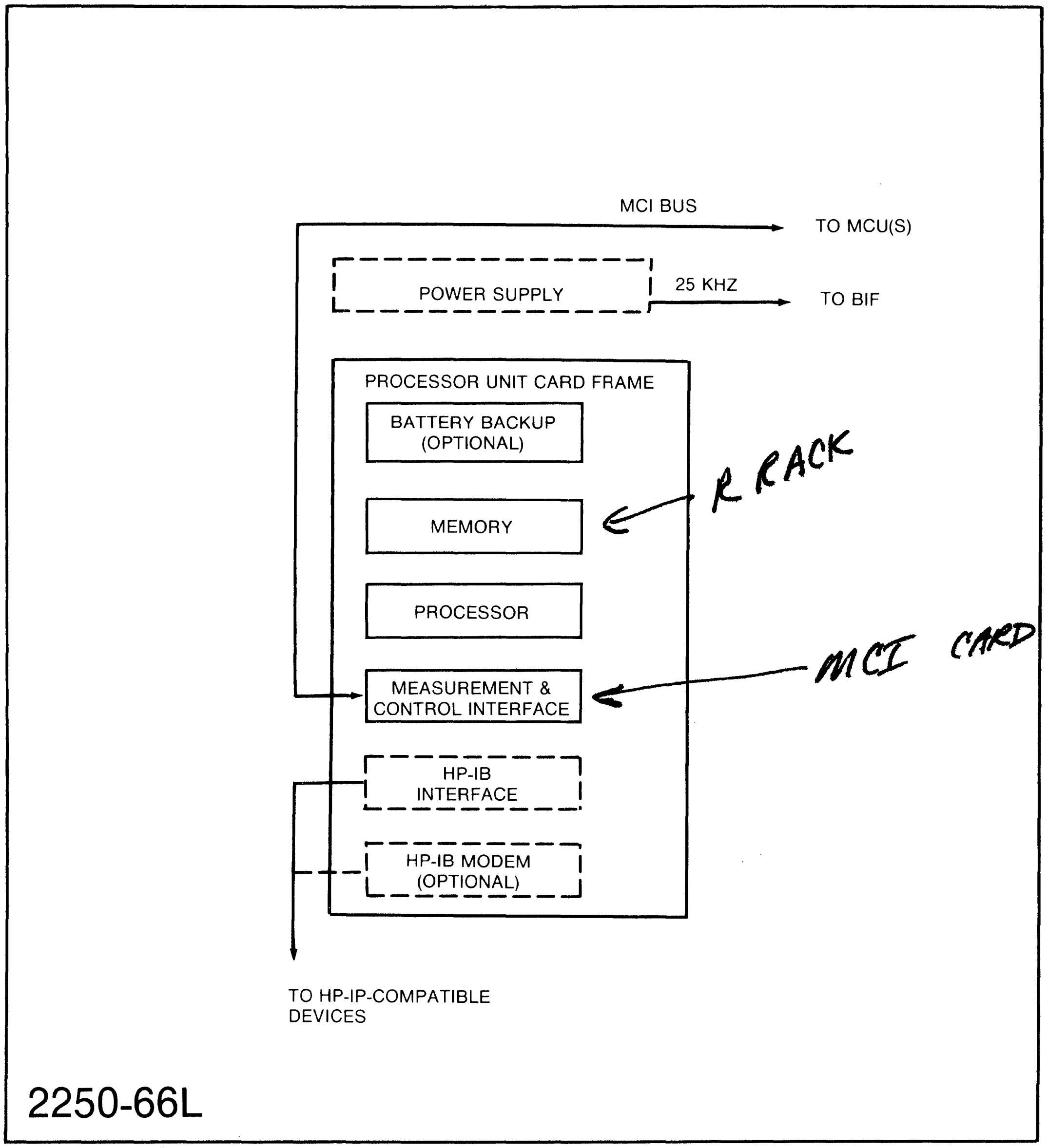


Figure 2-3. HP 2104 Processor Unit Functional Block Diagram

The processor card operates from programs running in an external computer, and provides control of the HP 2250 and its function cards by executing instruction sets stored in the memory card ROM. The processor card also controls data transfers (including Direct Memory Access (DMA)), processes I/O interrupts, provides self-test instructions, and performs all necessary computations. The major component on the processor card is a 64-pin Silicon-On-Sapphire (SOS) integrated circuit which contains much of the processor logic. This IC is called the CPU chip.

The processor card provides synchronous control using clock signals which are generated by the processor card.

The memory card provides ROM memory for the HP 2250 firmware and RAM user memory for application programs. The ROM word size is 16 bits and the RAM memory is 17 bits (it has an additional bit for parity). The 16-bit wide memory corresponds with the HP 12001D Processor requirements. The parity bit provides a means to maintain integrity of data in the RAMs.

The memory card and processor card plug into a common backplane.

The RAM memory operates in three modes:

a. Write cycle.

b. Read cycle.

c. Refresh cycle.

The ROM operates only in the Read cycle, because its memory permanently contains the processor's firmware. Memory read and write cycles are initiated by the processor card, while RAM refresh cycles are initiated by the memory itself to maintain its contents.

The memory can be addressed either directly or relatively (also called mapped addressing). The address word has 16 bits which comes from the processor over the backplane on the address bus.

Mapped addressing is a general term describing the addressing operation, and includes "Stack Addressing" and "Offset Addressing" described below.

Stack addressing is a form of mapping where the memory instructions access a "window" of data that automatically moves through memory. Automatic movement through memory is accomplished by successive increment or decrement operations.

Offset addressing occurs when a program statement contains an address which is merely a pointer to another address in memory (the address is stored in a register which is then used to access the offset address).

The dynamic RAM elements require refreshing in order to retain data. Refresh is accomplished by issuing a read strobe pulse to all the RAMs at regular intervals. The memory controller performs the refreshing by addressing each row of bits separately and issuing a refresh read pulse.

The parity generation/detection circuit provides parity information for data as it is stored into memory, and checks data being accessed from memory for correct parity. The circuit monitors the data bus directly (without buffering) so that the parity being checked is checked on the backplane as it is accessed by the processor.

The memory card will continue to read and write without interruption after a parity error. It is up to the card receiving the parity error information through the parity signal line to determine what action should be taken.

The HP 12071A Measurement and Control Interface (MCI) card performs the following functions:

Generates address words with address control signals which are used to select or scan input or output channels or points on the function cards.

Provides timing. The MCI card has internal timers for various measurement pacing modes. The internal timers are supplemented by an external pacing line to precisely control the rate at which measurement and control events occur, independently of processor timing. Internal and external pacing assures that the proper data passes through the card's data register at the right time, transferring between the MCU and processor backplanes.

Manages its own controller backplane I/O, responding to its firmware instructions, and from these it provides the required MCU backplane control signals to the function cards. It also receives function card handshake signals, function card interrupts, and function card data from the MCU backplane.

Interprets processor control instructions; e.g., Direct Memory Access (DMA) word transfers.

An I/O Master chip on the MCI card processes I/O instructions and DMA operations independently for that card, relieving the computer of this function. This arrangement eliminates restrictions on the number or the type of devices or interfaces using DMA.

The I/O Master detects the card's select code in address words from the computer independently of the card's position in the backplane. This is possible because the card's address is stored in a Global Register contained in the I/O Master. The select code is entered via a set of switches on the card.

Priority of I/O interrupts and DMA backplane acess is established by the I/O card's position in the processor unit. The slot next to the processor card has the highest I/O priority. From this slot the I/O interrupt priority numbers successively increase (less priority) as the slot numbers increment. Therefore, due to the MCI card's location, it has the highest I/O card priority of the controller section.

For more information concerning programmed I/O and DMA transfers, and a detailed description of the I/O Master, refer to the HP 1000 L-Series Interfacing Guide, part number 02103-90005.

The addressing circuits on the card consist of an Address Latch for the upper-eight address word bits, an Address Counter Latch for the lower-eight address word bits, an Address Decoder for MCI card internal registers, and an Address Buffer for channel or point addresses to be transferred onto the MC Bus.

Input and output data transfers are passed through a bidirectional data register.

The HP 12009A HP-IB Interface provides an interface between the HP 2250 and an external computer (controller). Up to 14 additional devices can be connected to the HP-IB. (HP-IB is the Hewlett-Packard implementation of IEEE Standard 488-1975, "Digital Interface for Programmable Instrumentation," and ANSI Standard MC 1.1. The HP-IB is a standard method of communication for HP computers and HP-IB-compatible instruments.)

The HP-IB card plugs into a single slot of the processor unit card frame and is assigned only one select code. The HP-IB card is connected by cable to the HP-IB devices or system controller which may be a Hewlett-Packard computer system. To the processor unit, this card is an I/O card and is under the processor card's control at all times.

The HP-IB card has the capability of handling its own Direct Memory Access (DMA) and of decoding its own instructions from the processor unit. These features are performed by an I/O Master chip located on the HP-IB card.

All interfaces to the processor unit backplane and to the HP-IB devices are provided by two integrated circuit chips. The first chip, the I/O processor (IOP) chip, manages all I/O functions of the backplane. The second chip, the PHI (Processor to HP-IB Interface) chip performs all data and control signal interactions with the HP-IB devices. Through the use of these two chips, the HP 12009A HP-IB Interface relieves the processor of most of the HP-IB protocol processing.

2.2.1 Addressing-Talking-Listening-Handshaking

A technique of addressing is used to determine which device is to "talk" and those devices that are to "listen". Data is sent from one device to another device in a bit-parallel, byte-serial format using an interlocked remove data before the receiver has finished using the data. It also ensures that data is not lost when devices having inherently different speeds communicate on the same bus.

Definitions of different types of "talker" or "listener" devices are listed below.

TALKER - Any device that is capable of sending or transmitting information on the bus. There can be only one talker at a time on the bus.

LISTENER - Any device that is capable of receiving or accepting information on the bus is a listener. There may be up to 14 listeners at the same time on the bus.

TALKER-LISTENER - Any device that has the capablility of both sending and receiving information on the bus as defined previously is both a talker and listener. For example, a counter is a talker when sending data and a listener when it is being programmed.

CONTROLLER - Any device that has been programmed to have the responsibility of managing the flow of information between devices connected to the bus is an HP-IB controller. It is capable of addressing one of the devices as a talker and one or more of the others as listeners. The HP-IB permits a system to have more than one controller, but only one controller may be active at a time.

SYSTEM-CONTROLLER - An HP-IB System Controller for the HP 2250 is always a computer system such as the HP 1000. The System Controller can be installed in the HP 2250. This is the optional HP 1000 L-Series Computer installed in the second card cage adjacent to the HP 2250 processor unit card cage.

Section III
HP 2251 Measurement And Control Unit

3.1 INTRODUCTION

This section contains information on the HP 2251 Measurement and Control Unit (MCU). The MCU, see figure 3-1, consists of a card frame which contains a Backplane Interface (BIF) card and up to eight I/O (function) cards. Up to eight MCUs can be included in an HP 2250 Measurement and Control Processor, depending on the HP 2250 configuration. See Section 1 for descriptions of the various configurations.

Information covering the individual function cards is contained in separate sections, as follows;

Section IV -- HP 25501A 16-Channel High-Speed Analog Input

Section V -- HP 25502A 32-Channel High-Level Multiplexer

Section VI -- HP 25503A 32-Channel Low-Level Multiplexer

Section VII -- HP 25504A 16-Channel Relay Multiplexer

Section VIII -- HP 25510A 4-Channel Voltage/Current Analog Output

Section IX -- HP 25511A 32-Point Digital Input

Section X -- HP 25513A 32-Point Digital Output

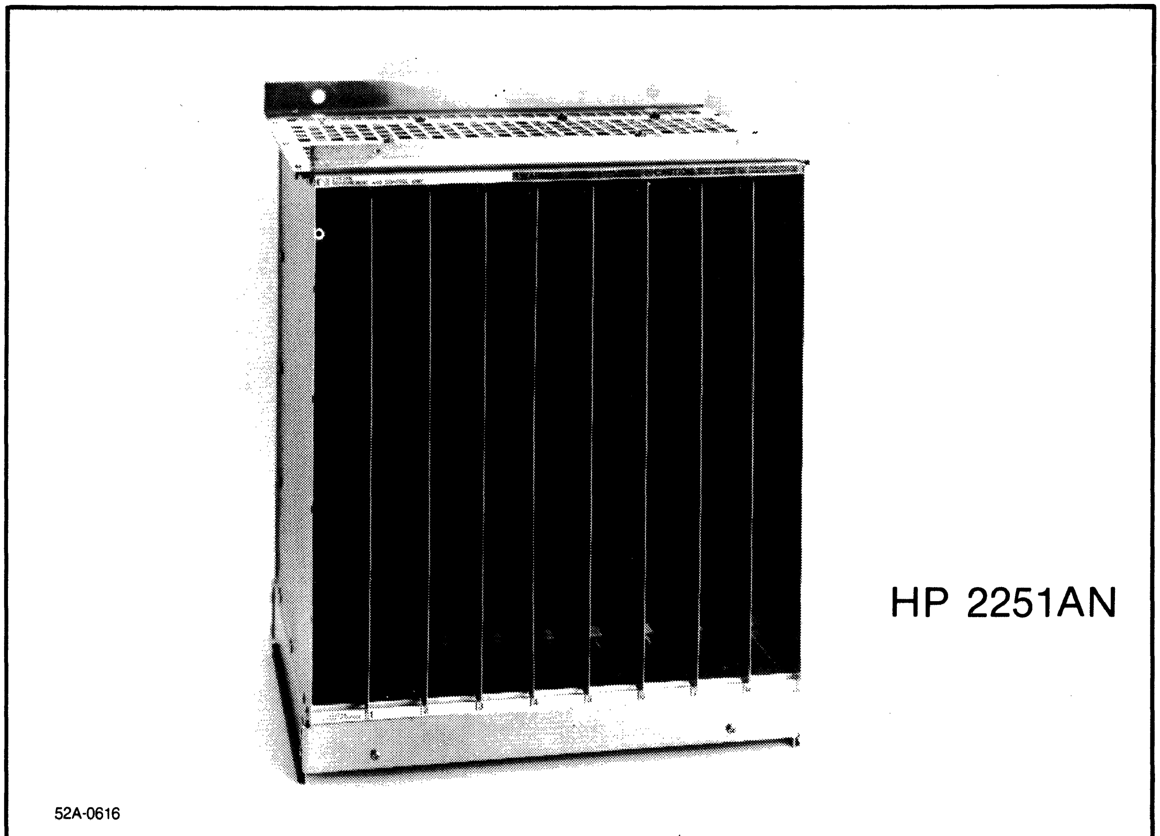
Section XI -- HP 25514A 16-Point Relay Output

Section XII -- HP 25516A 16-Point Digital Multifunction

Section XIII -- HP 25594A Thermocouple Reference Connector

Section XIV -- Signal Conditioning Modules

Briefly, the purpose of the MCU is to interface the function cards from external sensors and actuators to the HP 2104 Processor Unit. This is accomplished by means of the Backplane Interface (BIF) card.



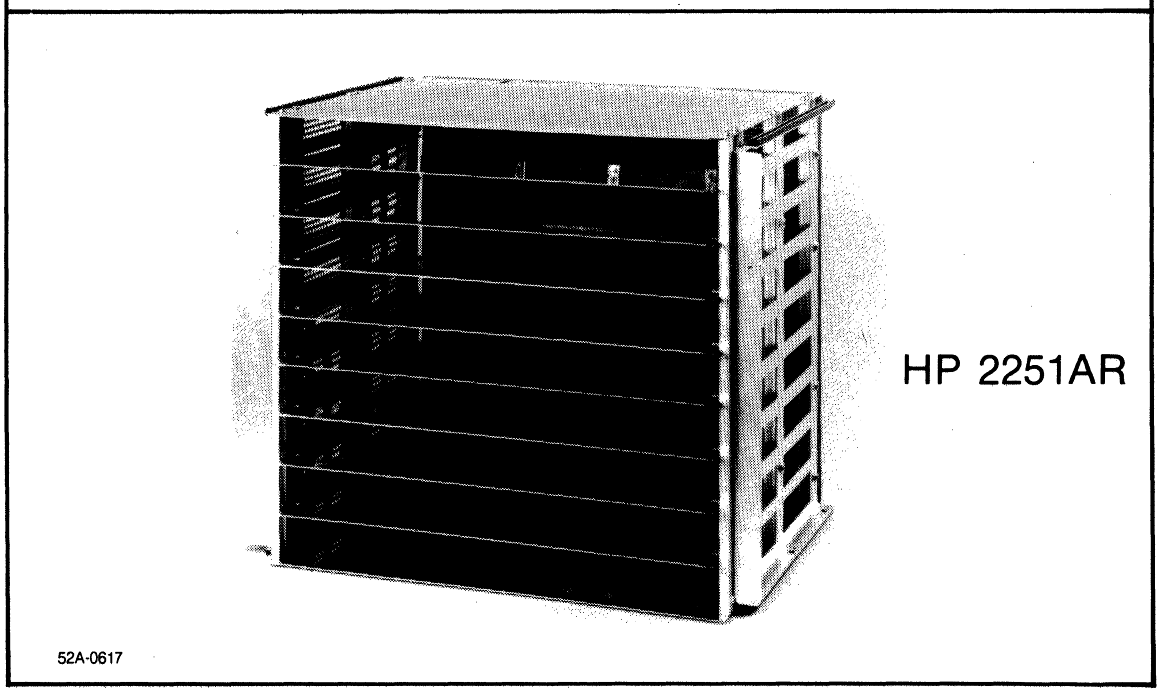


Figure 3-1. HP 2251AN and HP 2251AR Measurement and Control Units

A measurement and control interface (MCI) bus connects the HP 12071A Measurement and Control Interface (located in the processor unit) to a backplane interface (BIF) card in each MCU.

A power bus connects power from the HP 12035A Power Supply to the BIF and from there to the function cards. Thus, the BIF provides a signal interface between the function cards and the MCI in the processor unit, and a power interface between the function cards and the power supply.

3.2 MCI BUS DESCRIPTION

The measurement and control interface (MCI) bus connects the MCI to one or more BIFs, depending on the number of MCUs in the HP 2250 (each MCU contains one BIF). The BIFs connect to the function cards through a backplane. The configuration of power bus, MCI, MCI bus, BIFs, and function card backplane is shown in figure 3-2.

The card frame containing a BIF and the function cards it serves also contains the function card backplane; together these items (card frame, BIF, function cards, and function card backplane) comprise an MCU. Nine card slots in the card frame have numerical designations from 0 through 8.

The BIF is always in the first slot (slot 0) of the MCU. The mainframe card group (function cards and BIF) is physically "MCU 0" and is usually also designated as logical "MCU 0." The first additional MCU is usually "MCU 1," etc. The MCU address is set by a thumbwheel switch on the front edge of the BIF. MCU addresses do not have to agree with the physical location of the MCU. The MCI can communicate with up to 8 MCUs for a maximum of 64 function cards.

The BIF provides the function cards with signal buffering, partial address decoding, interrupt masking, and 25 kHz power. In a system consisting of more than one MCU, the MCI and power buses connect through each BIF to the downstream MCUs in a "daisy chain" fashion.

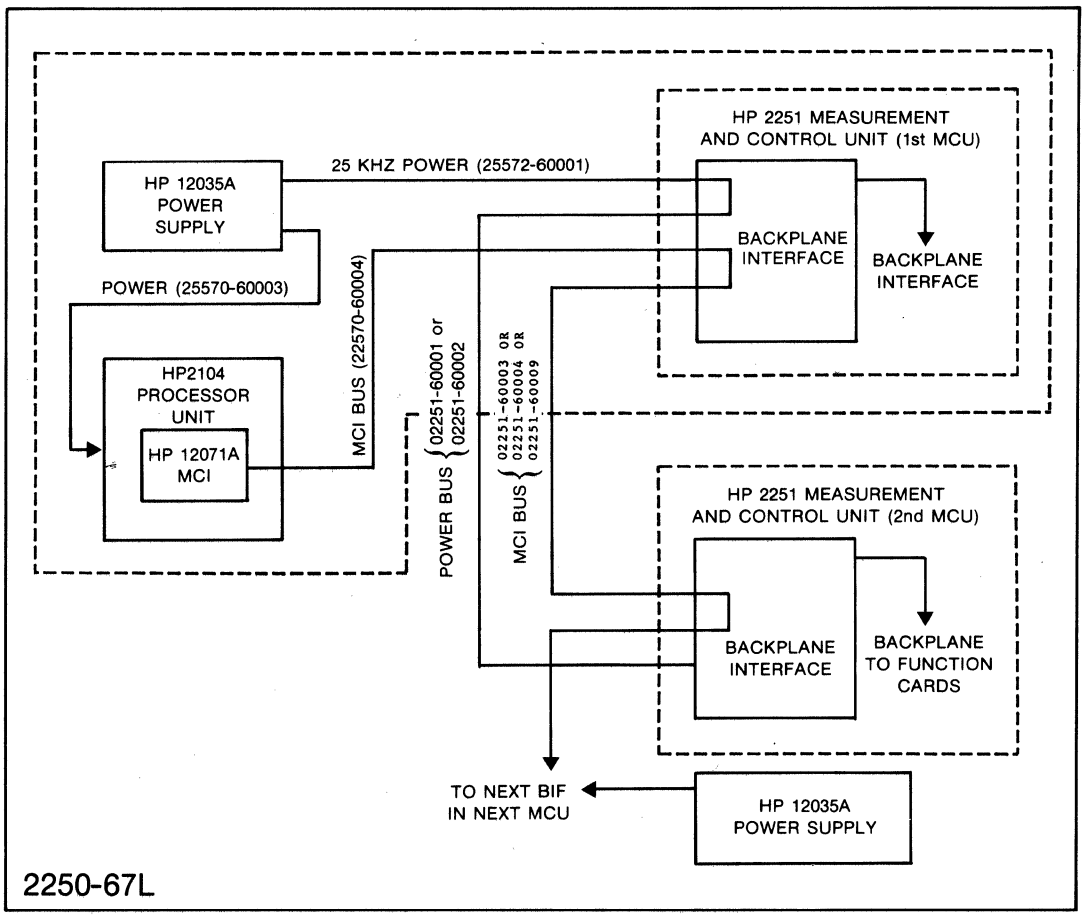


Figure 3-2. HP 2250 Bus Configuration

3.3 MCU BACKPLANE SIGNALS

The MCU backplane consists of 16 data lines in addition to control lines, system clock lines, control common lines, power bus lines, and several spare lines. The signals are defined in table 3-1.

MCU and backplane operation in reference to the MCI and BIF is described in the following paragraphs.

All signals except clocks are inverted as they enter and leave a card. Negative true versions of signals are designated with a minus sign suffix. For example, ADS-.

3.3.1 Clock Signals

A 2 MHz clock signal (TMHZ) originates in the MCI and synchronizes ACYC (Advanced Cycle) on its rising edge. Both TMHZ and ACYC are transmitted via the MCI bus to the clock circuit of the BIF.

The BIF clock circuit delays ACYC half a cycle of TMHZ and generates a new signal on the falling edge of THMZ to form CYC (Cycle). The MCI card generates its own version of CYC so it can synchronize its operation with the function card's operation. The system clock TMHZ, ACYC, and CYC are buffered and sent to each function card via the function card backplane.

The reason for the separate clock signals is that the THMZ square wave is too fast for MCI bus data communications; yet is required by some of the function cards. The ACYC and CYC signals are 500 kHz, 25 percent duty cycle signals. All control MCI bus signals are valid only on the rising edge of THMZ when CYC is high, and all transitions of non-clock signals occur on the first rising edge of TMHZ immediately following the high CYC. The signal ACYC on the function card backplane is ahead of CYC by 45 degrees (250 ns) and is only used to latch input data on some cards.

A pulse detector monitors the TMHZ line on the BIF and connects a 25 kHz, square wave to the function card backplane TMHZ line whenever the 2-MHz square wave of TMHZ is missing. This circuit also drives the CYC line continuously true.

Table 3-1. MCI Bus and Function Card Backplane Signals

SYMBOL	DESCRIPTION
	NOTE: MCI bus signal unless otherwise noted.
ACYC	Advanced Cycle: Generated by MCI card on rising edge of TMHZ, generates CYC and latches input data on some cards.
ADS-	Address Strobe: Used by BIF to decode the multiplexed address and data on data bus D1 through D16. At start of MCI bus cycle, ADS is true for 2 usec when address is on bus. No function card is enabled at that time.
COM	Common Line (not a signal): Provides common signal path for cards.
CYC	Cycle of TMHZ (function card backplane): A 500 KHz, 25% duty cycle signal going to function cards. Selects cycle of TMHZ to use for timing.
D1- thru D16-	Data Bus: 16 bidirectional Data Lines.
DATS-	Data Strobe: Tells function cards when the MCI is ready to send or receive data (used in conjunction with RESP from function cards).
DPWR	Driver Power: Backup +12 Vdc to disable backplane drivers when power is lost. Minimizes the effect of power off.
EN1- thru EN8-	Enable (Function card backplane): Selects function card to be active during current backplane operation. EN is true during a read or a write from end of appropriate address strobe until beginning of next address strobe.

Table 3-1. Measurement and Control Backplane Signals (Continued)

SYMBOL	DESCRIPTION
	NOTE: MCI bus signal unless otherwise noted.
ENA-	Enable All: Simultaneously selects certain types of function cards to be active during a backplane operation. Used only for global write commands (no data returned).
FIN-	Function Interrupt: Set high by BIF on interrupt from one of its function cards. MCI card sees FIN, then identifies which card interrupted by reading BIF interrupt registers (low 8 bits = slot address, upper bits = unmask). One or more bits are true corresponding to interrupting cards (Bit 1 = card 1, Bit 2 = card 2, up to Bit 8 = card 8).
FINT1- thru FINT8-	Function Interrupt (function card MCI bus): FINT goes true when the card wants service. FINT goes false after the card interrupt status is read by MCI card. There is one FINT line from each function card to the BIF.
IEX-	Immediate Execute Enable: Measurement strobe, synchronized to CYC, is examined by currently enabled card. Allows interrupting routine to issue a measurement strobe to a single card.
RA1- thru RA8	Register Address Bus from BIF to function cards: When ADS is true, BIF latches eight low order bits of MCI bus data bus onto register address bus, holding this address until next ADS.
RIM	Read Immediate: Driven true by MCI to read a function card register without changing previous address latched into the card. Cards must respond immediately to an operation accompanied by RIM.
RESP	Response: Driven true by function card when ready for data transfer to or from MCI card.
SWT-	Second Word Transfer: Set true by MCI card coincident with second DATS when a second word is to be transferred to or from same register address. (DATS and RESP set time of actual transfer.)

Table 3-1 MCI Bus and Function Card Backplane Signals (Continued)

SYMBOL	DESCRIPTION
	NOTE: MCI bus signal unless otherwise noted.
SYN-	System Normalize: Returns all function cards to their "power on" state (initialized condition).
TMHZ	Two Megahertz Clock: The frequency of the main system clock is 2 MHz for timing of function card state machines.
TST-	Test: Set by the MCI during "power on" self test to stop BIF from enabling any function card.
WRT-	Write: Identifies "write" cycle on MCI bus for external and function card circuits when true. A "read" cycle is when WRT is false. WRT is also true during Address strobe on both write and read operations.
XCUT-	Execute: An internal measurement strobe, synchronized to CYC, which is looked at by all function cards (all function card measurements are initiated by XCUT or IEX).

These substitute signals are not intended to allow normal MCU operation but are to provide clock-signal edges for resetting logic circuits on the function cards so they will restart in known conditions. For example, the backplane interface circuit on each function card has a synchronous reset input which must have a positive-going clock edge while CYC is true in order to reset properly. Switchover from the 25 kHz signal to a 2 MHz signal occurs only when both signals are low.

A pair of LED indicators on each BIF shows various conditions. One LED is green and indicates that the BIF has power and clock signals and is connected to the MCI bus and the 25 kHz supply bus. The other LED is red and indicates abnormal operation which is most likely one of the following conditions:

a. 25-kHz power is not connected to the BIF but the control cable is connected and the MCI power is on.

b. The "daisy chain" of the control cable is broken somewhere between the BIF and the MCI, but 25-kHz power is connected to the BIF.

c. +12V supply on the BIF is not operating correctly.

d. Clock circuits on the BIF are not operating correctly.

e. Clock circuits on the MCI are not operating correctly.

f. Power cable connected but control cable is not.

If both indicators are off, then either the system power is off, or both the power cable and the 50-line control cable to the BIF are disconnected at some point in the chain.

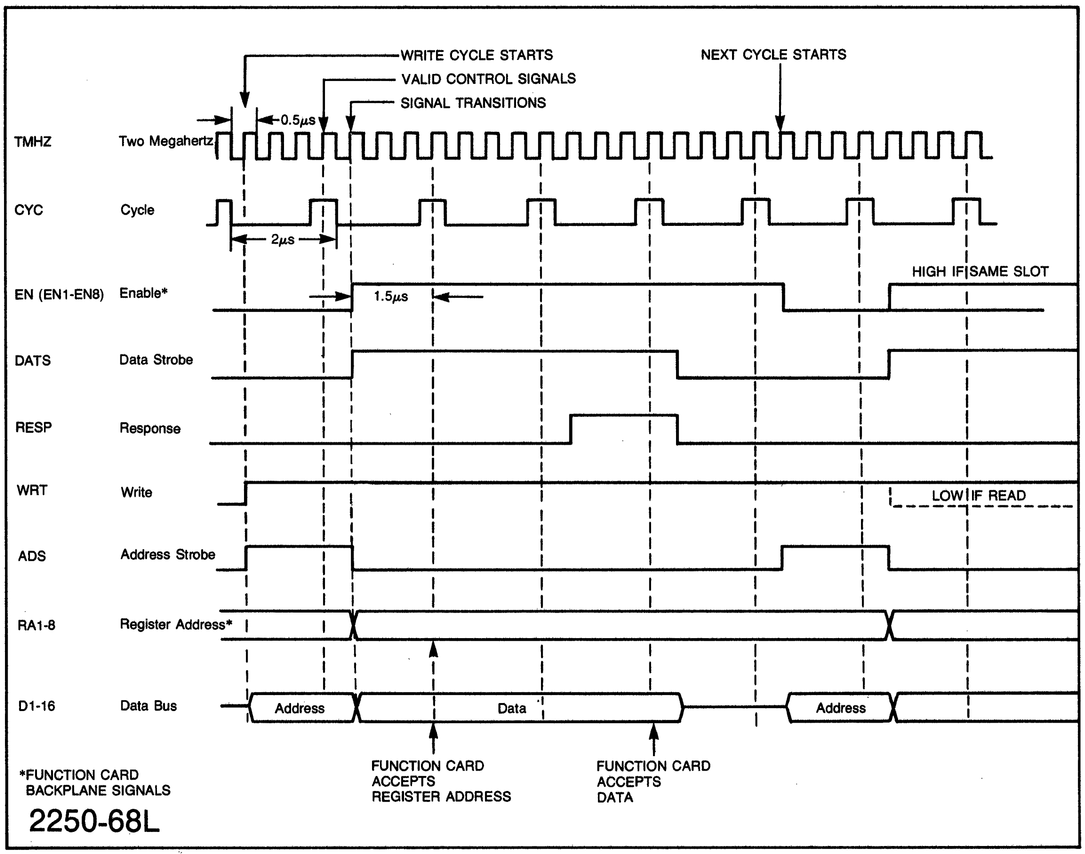
3.3.2 Initialization Signal

A circuit on the BIF called "Power-on/System Normalize" issues a pulse labeled SYN when the power comes on. SYN is also generated by MCI bus signal MSYN from the MCI card. SYN sets several circuits on the BIF and function cards to their initial state and loads all zeros (0s) into some registers.

3.3.3 Write Operation Signals

In the write operation, a signal handshake is used to assure orderly transmission of data from the MCI card to a function card. A write operation is usually employed for measurement control or output control commands. The write signals and handshake exchange between MCI card and function card, and signal timing are shown in figure 3-3.

The following is a description of the "write" operation when the MCI card has data for a function card: A write operation starts when the ADS (address strobe) line goes true and the WRT (write line) goes true, or stays true if the preceding cycle was a write. ADS stays true for 2 microseconds. At the same time a 7-bit function card address is placed on the upper eight bits of data bus (D1-D16). The BIFs decode the address and one BIF selects one enable output (EN1-EN8). The lower eight bits of D1-D16 contain an input/output register address which is latched onto the function card bus lines RA1-RA8.



CONDITIONS OF DIAGRAM:
1. SINGLE WORD TRANSFER.
2. FUNCTION CARD IS READY TO ACCEPT THE DATA.
3. POSITIVE TRUE SIGNALS SHOWN AS THEY APPEAR ON THE BIF AND FUNCTION CARDS.

Figure 3-3. Write Handshake Signals and Timing

At the time when ADS goes false, the BIF enables the selected function card by driving the previously selected (one-of-eight) function-card bus enable line (EN1-EN8) with a true signal. With EN true during the next active clock qualifier (CYC), the function card accepts register address RA1-RA8, if the function card is finished with the previous register address.

An exception to this is when the MCI card issues MCI bus signal ENA for global writes. Every function card which can accept a global write cycle responds as if it were enabled by its own unique EN signal.

Also when ADS drops, the MCI card usually starts a handshake by raising DATS (data strobe) while it places data on the D1-D16 data bus. (In some special cases, there is a short delay between ADS and DATS.) After two CYCs, and if the addressed function card is ready to be written to, the card's write/read control circuit generates RESP (Response) on the MCI bus which tells the MCI card that the function card is accepting the data (handshake reply). The actual acceptance of the data occurs on the rising edge of TMHZ during the true CYC signal preceding the end of RESP and DATS by one full cycle of TMHZ.

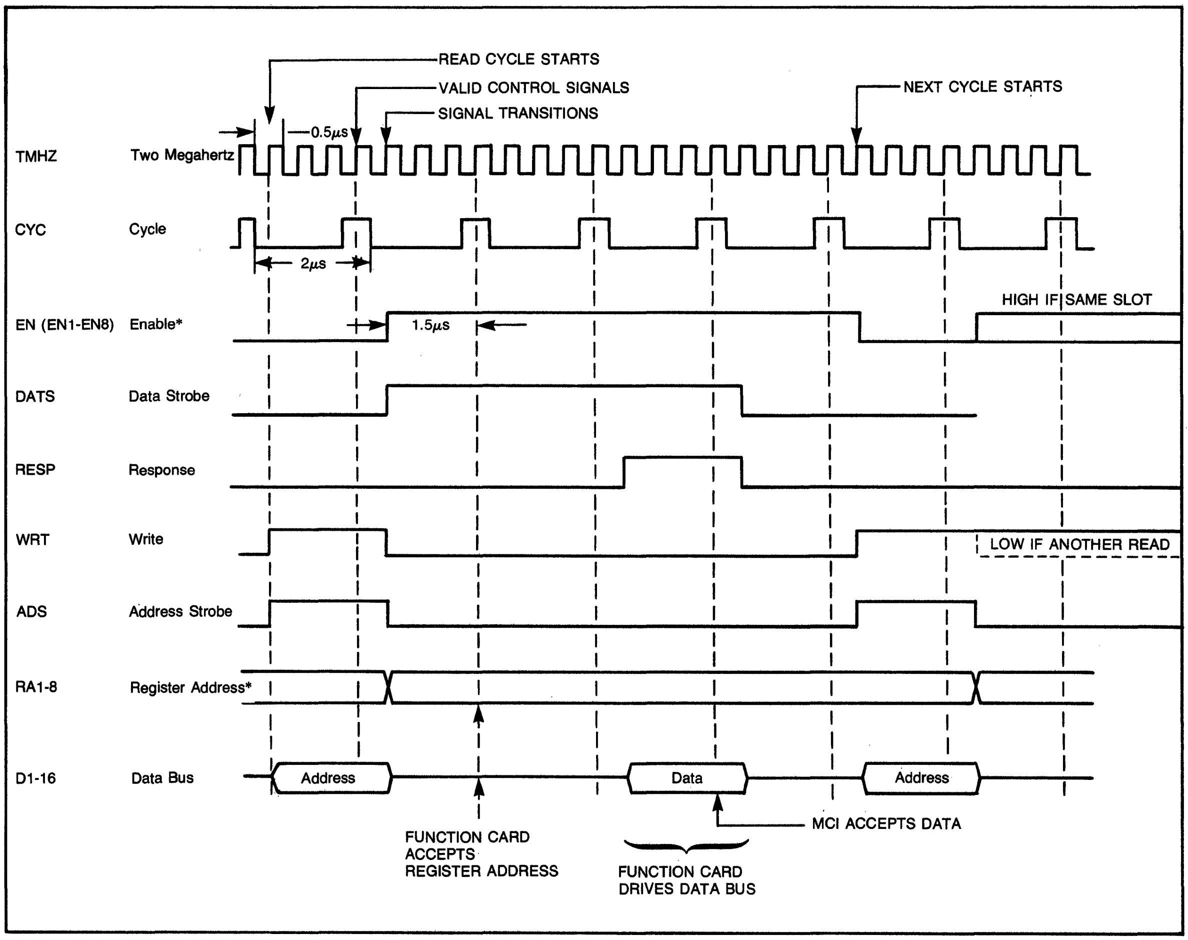
The EN signal remains true during DATS and RESP and remains true until the next read or write operation (beginning of next address). The next cycle begins when ADS goes true again. If a second word is to be written, a line called SWT (Second Word Transfer) goes true and the WRT line remains true.

3.3.4 Read Operation Signals

The read handshake and timing is very much like the write operation described above except that the function card is the source of data. It is used where the function card has measurement or status data to send to the MCI card. The read signals and handshake between MCI card and function card, and timing signals are shown in figure 3-4.

The read operation covers the time between the start of one ADS signal and the next ADS. When the ADS line goes true, the function card address is placed on data lines D1-D16. To write the address on the card the WRT line goes true (or stays true if the preceding cycle was a write). The BIF decodes the address and selects one of the eight enable lines (EN1-EN8).

The input/output card register address for the data being written is contained in the lower eight bits of D1-D16, which is latched onto the function card MCI bus lines RA1-RA8.



CONDITIONS OF DIAGRAM:
1. SINGLE WORD TRANSFER.
2. FUNCTION CARD IS READY TO DRIVE THE DATA.
3. POSITIVE TRUE SIGNALS SHOWN AS THEY APPEAR ON THE BIF AND FUNCTION CARDS.

Figure 3-4. Read Handshake Signals and Timing

The MCI card sets WRT false and DATS true, indicating it is ready to accept data (handshake starts), and the BIF enables the function card by raising the previously selected enable line (EN1-EN8) on the function card MCI bus.

The RESP signal of the function card goes true at the same time data lines D1 - D16 are available, telling the MCI card that data is ready to be read (handshake ends). The MCI card accepts the data during this time on the rising edge of TMHZ while CYC, RESP, and DATS are true. Then RESP and DATS go false. The operation ends with its enable line going false and the MCI bus is ready for another address. The WRT signal will change to true at the beginning of ADS.

3.3.5 Measurement Strobes

All measurement input and output commands must have a measurement strobe to complete execution. (Miscellaneous commands to configure the card, to read status, etc., do not use a measurement strobe.) There are two measurement strobe lines on the MCI bus, IEX (Immediate Execute) and XCUT (Execute). IEX is used to cause command execution at the time of data transfer, and XCUT is used to cause command execution sometime after the data handshake.

The IEX signal is accepted only by the currently enabled card; therefore, the interrupting routine can use a card without knowing the state of other cards. The IEX signal is normally "true" when a card is enabled, and any measurement command at that time will be carried to execution right away. If IEX is "false," any command at that time will set up the card for completion when the XCUT strobe occurs. If IEX has been commanded to be "false," it will turn to "true" again automatically at the end of the task, or sooner if specifically turned on by a command.

The MCI sends XCUT as a strobe signal which is accepted by all function cards whether they are enabled or not. Any card which was set up by a measurement command while IEX was false (measurement strobe off) will delay execution of that command until receipt of XCUT or a later command with IEX. Upon receiving XCUT, the card will immediately complete the command. For output commands, all the set up outputs change when XCUT is received.

For input commands, the data transferred at the time of the first command with IEX false will not be the desired data. The desired input data will be input at the time of XCUT which must be followed by a normal read command.

Both IEX and XCUT are synchronized to CYC. On the function cards, both IEX and XCUT generate an internal card signal to be used in conjunction with the card's strobe circuits for pacing and reading data.

3.4 BACKPLANE INTERFACE (BIF)

The Backplane Interface (BIF) card is the interface between the MCI bus and the function card backplane which distributes the MCI bus signals to eight function cards in the MCU. A BIF must be installed in the first slot of every MCU. The backplane interface card is shown in figure 3-5.

3.4.1 Function Card Addressing

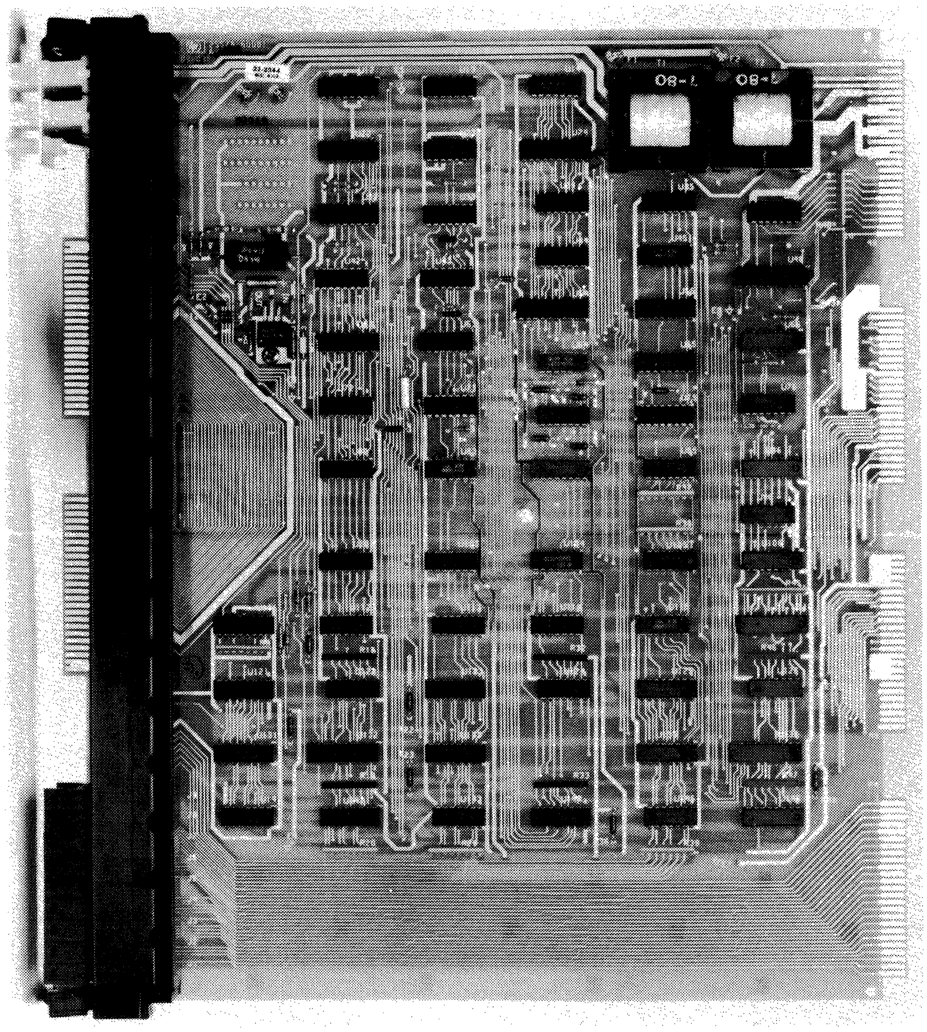
The desired function card is selected by MCU and slot number using seven bits of the 15-address bits. (Four bits select one out of eight MCUs, three bits select one out of eight card slots.) The remaining eight bits are the register address bits, RA1 through RA8, which select individual inputs and outputs on the function cards.

The 4-bit MCU address is entered on a 16-position rotary switch having a 4-bit binary output representing the address of the MCU.

3.4.2 Theory of Operation

A block diagram of the BIF circuitry is shown in figure 3-6. It contains data buffers, control buffers, interrupt register, address latches, address decoding circuits, and power supply.

Both the data words and 15-bit function card addresses are transmitted over the same data bus on the MCI bus. Data and addresses are separated by demultiplexing on the BIF, and the current address is stored in the 15-bit address latch.



2250-30H

Figure 3-5. Backplane Interface Card

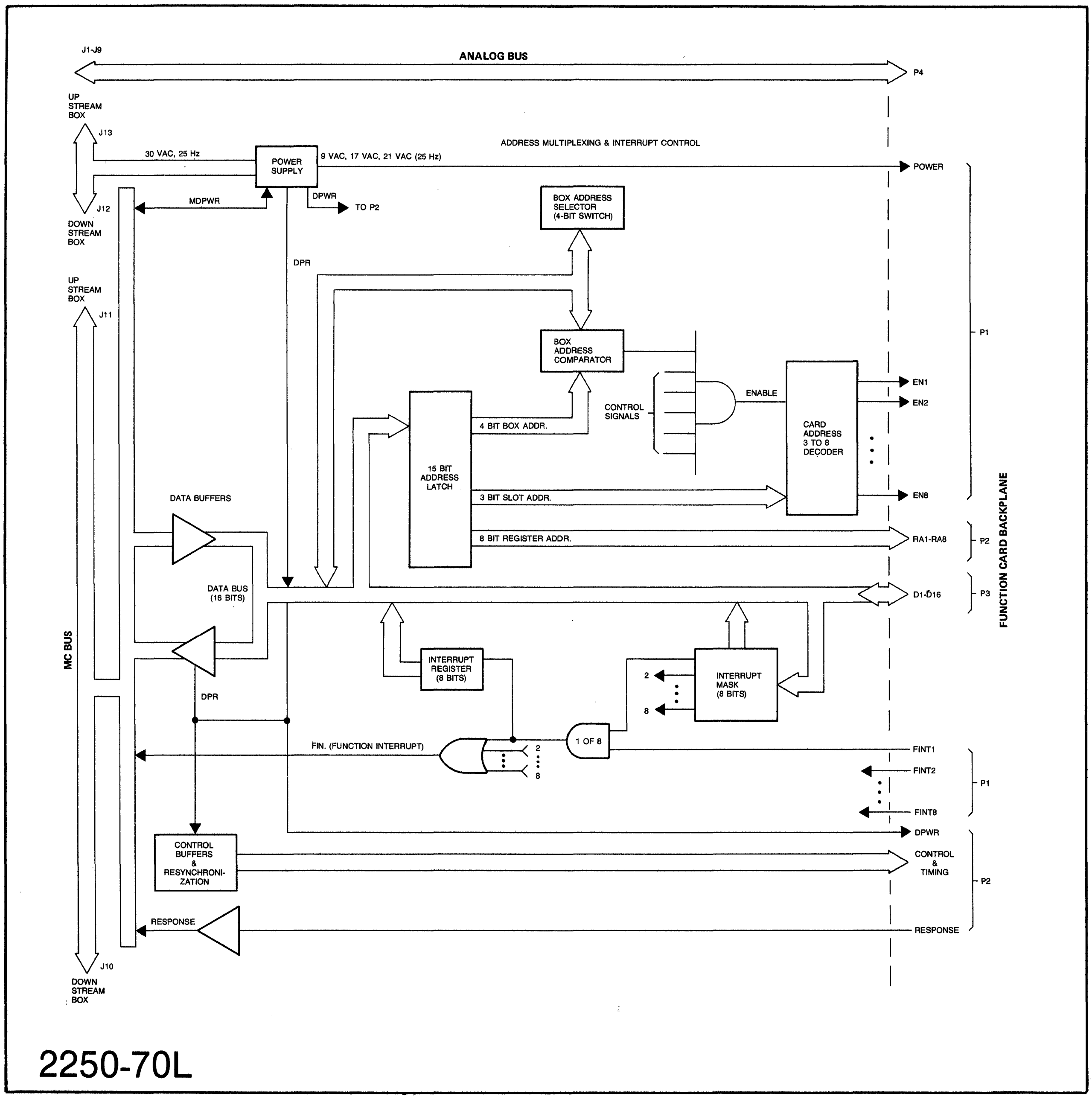


Figure 3-6. "Backplane Interface" Block Diagram

BIF

The address from the data bus appears on one side of the BIF address comparator, and the BIF address appears on the opposite side of the comparator. When the addresses match, the BIF address decoder is enabled. Three of the 15-bits in the address latch contain the slot address transmitted on the MCI bus. If that particular BIF is enabled as described above, these bits are decoded to one-of-eight enable lines (EN1 through EN8). The enable signal will "wake up" the addressed function card so it will communicate with the MCI card through the MCI bus as explained above under Write Operation Signals and Read Cycle Signals.

The 16-line data bus to the function cards is isolated from the MCI bus by bidirectional tri-state (true/false or open) buffers. The lines on the measurement and control MCI bus (toward the MCI) are designated MD1 through MD16. The lines on the function card bus (toward the function cards) are designated D1 through D16.

The address format of the MCI bus and function card MCI bus lines is illustrated below:

ADDRESS FORMAT

NOT USED	1 OF 128 SLOTS IN SYSTEM		1 of 256 POSSIBLE REGISTERS ON FUNCTION CARDS
	1 OF 16 MCUs ONLY 8 USED	1 OF 8 SLOTS	
BITS 16	15 14 13 12	11 10 9	8 7 6 5 4 3 2 1

16 MCU'S IS CAPABILITY OF ~~[illegible]~~ MCI

3.4.3 Interrupts

There are eight interrupt lines, one from each function card slot, designated FINT1 through FINT8. The bits on these lines are ANDed with the bits of the interrupt unmask register to allow only the unmasked interrupts to be stored in the interrupt register. The interrupt unmask allows only certain slots to be enabled so they can interrupt the system for service. Unmasking is set up through programming an "unmask" data word, usually at initialization of system operation.

One or more unmasked function card interrupts (function card bus signals FINT1-FINT8) will generate the MCI bus signal FIN (Function Interrupt) to the MCI card. The system recognizes FIN and, when ready to identify the source of the interrupt, reads, one at a time, the interrupt register on each BIF in the system. It does this with a read cycle (same as any data read) addressed to register 256, which is the last register on the last page of any slot in the MCU of interest.

When a BIF detects register address 256 it disables all function cards in the MCU and responds to the read operation by placing the contents of the 8-bit interrupt register on the lower eight bits of the data bus (MD1-MD8), and the contents of the 8-bit interrupt unmask register on the upper eight bits of the data bus (MD9-MD16). It also drives the MRESP line. The interrupt register and unmask register information is encoded one bit per slot; that is, MD3 is true if slot 3 is interrupting, MD16 is true if slot 8 is unmasked.

Once an interrupt reaches the MCI card, it may be cleared only by reading the interrupt register on the interrupting function card. The MCI card reads the interrupt register on each BIF in the system to identify the interrupting slot or slots. The MCI card then reads the interrupt register on the interrupting card. Reading the interrupt register on the function card clears the register and clears the interrupt.

3.4.4 BIF Power Supply

The power supply on the BIF is energized from 17 Vrms, 25 kHz which comes from a small transformer on the card. The transformer is powered from the 27 Vrms, 25 kHz lines originating in the HP 12035A power supply. The 25 kHz power connects to the BIF on J12, and through it to downstream BIFs on J13 (or the opposite order of J13 and J12). A full-wave rectifier circuit followed by a filter is used in the BIF supply, providing a dc input to an IC regulator giving an output of +12V.

A line designated MDPWR on the MCI bus carrys 12 Vdc, continuously. If the BIF supply fails, the voltage (called DPR on the BIF) maintains power on the BIF clock resynchronizer and data bus drivers. MDPWR becomes DPWR in the BIF and connects through P2 to the function card backplane to power the function card bus drivers of any cards having a power suppply failure.

3.5 BACKPLANE WIRING

The locations of the connectors for the MCI bus and function card MCI bus are shown in the BIF block diagram (figure 3-6). The digital, analog, and control signal MCI bus and function card MCI bus wiring diagram is shown in figure 3-7. A comparison of these two figures illustrates the location and wiring of signal distribution between the BIF and the function card slots.

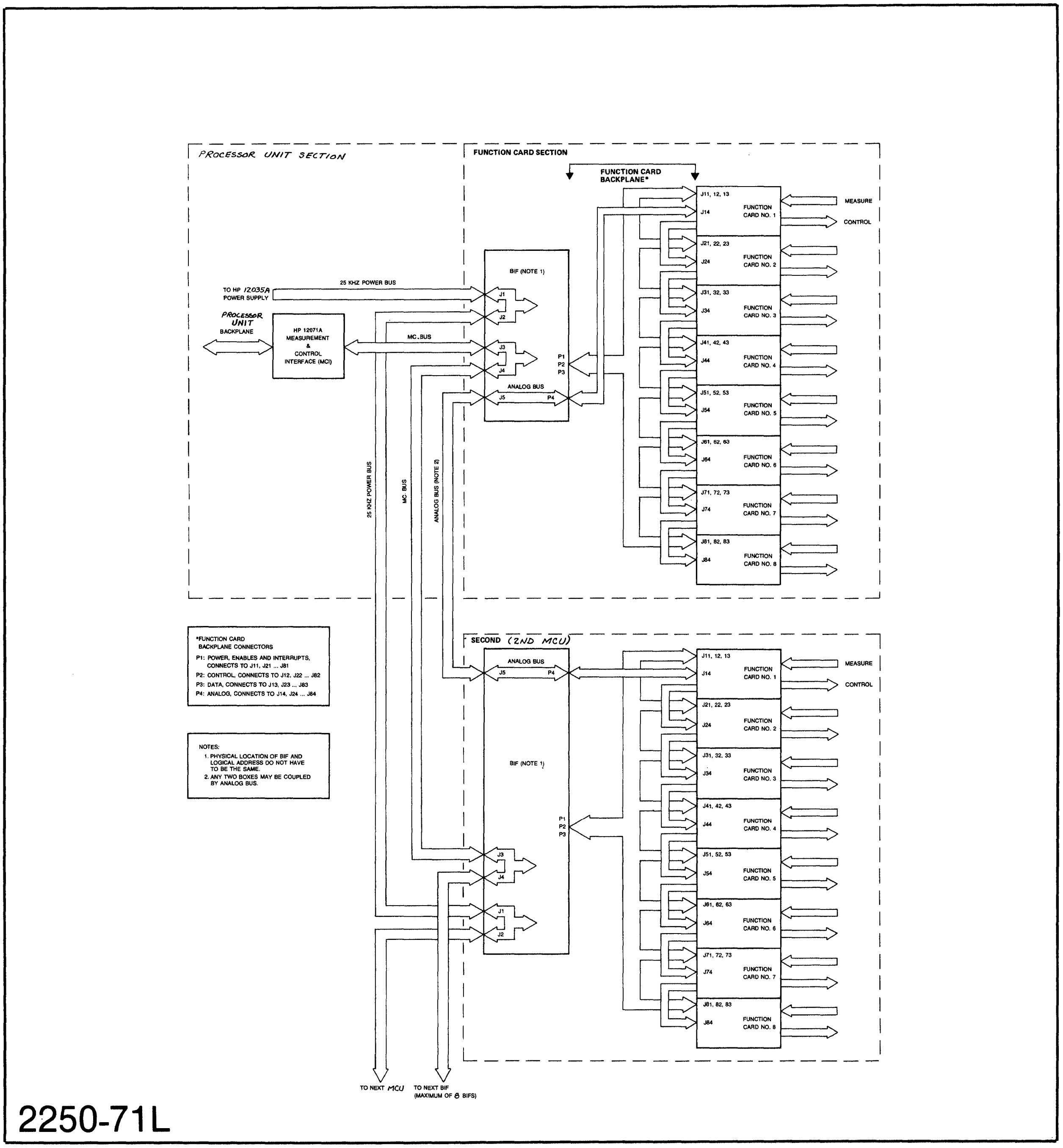


Figure 3-7. Data and Control Signal Backplane Diagram

Figure 3-8 shows the distribution of the individual enable lines (EN1-EN8), and the function card interrupt lines (FINT1-FINT8) to and from the eight function card slots. Table 3-2 lists the MCI bus signals in alphanumerical order for the signals defined in table 3-1.

3.6 POWER DISTRIBUTION

The power for the BIF cards is distributed as an ac voltage of 27 Vrms, 25 kHz from the HP 12035 power supply or from an additional power supply if additional MCUs are added to the system. The high frequency allows the use of small sized components to provide dc voltage for the card circuitry and gives the system higher noise immunity. The 27 Vrms enters each BIF on J12 or J13 through a 3-conductor cable, and is "daisy chained" to the next BIF through another cable connected to J13 or J12. The power cable part numbers are given in figure 3-2 (bus configuration). Power distribution is shown in figure 3-9.

Dc voltages of 15V, 12V, and 5V are required on the function cards. The BIF originates ac voltages for distribution on the function card MCI bus to the function card rectifier/filter/regulator circuits on the cards. A BIF supply transformer provides the following ac voltages to give the dc requirements: 21 Vrms center-tapped, 17 Vrms center-tapped, and 9 Vrms center-tapped at 25 kHz. The 25 kHz voltages connect to the function card bus through P1.

3.7 FUNCTION CARDS

The remaining sections of this manual (Sections IV through XIV) contain information on the function cards and signal conditioning modules available with the HP 2250 system. Function cards provide for analog and digital user applications. Field wiring provides connections from the function cards to the sensors and actuators, such as switches, relays, transducers, etc., in the user's application process.

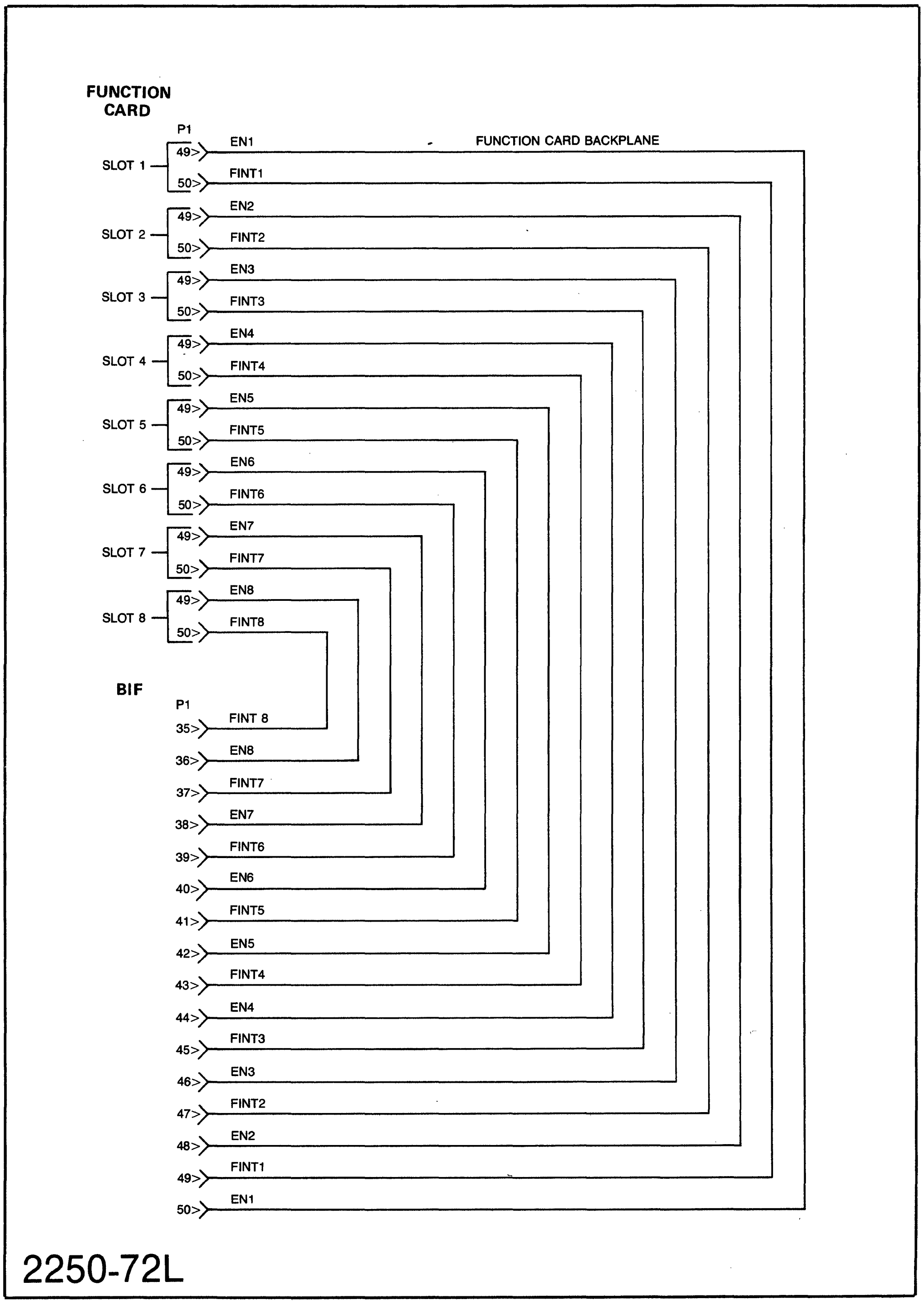


Figure 3-8. Distribution of Enable and Interrupt Lines

Table 3-2. Backplane Signal Distribution

MC BACKPLANE SIGNAL MNEMONICS	MCI BUS CONNECTORS	FUNCTION CARD BACKPLANE SIGNAL MNEMONICS	FUNCTION CARD BACKPLANE CONNECTORS		
	J10 & J11 except as noted		P1	P2	P3
MACYC	45 !	ACYC+		7*	
MACYCR	46 !	CYC+		9*	
MADS-	42 !	ADS-		27*	
MCOM	3,10,31, 37,44	COM			
MD1-	11	D1-			11
MD2-	12	D2-			12
MD3-	13	D3-			13
MD4-	14	D4-			14
MD5-	15	D5-			15
MD6-	16	D6-			16
MD7-	17	D7-			17
MD8-	18	D8-			18
MD9-	19	D9-			19
MD10-	20	D10-			20
MD11-	21	D11-			21
MD12-	22	D12-			22
MD13-	23	D13-			23
MD14-	24	D14-			24
MD15-	25	D15-			25
MD16-	26	D16-			26
MDATS-	41 !	DATS-		25*	
MDPWR	4 !	DPWR		45*	
MENA-	6 !	ENA-		29*	
		EN1-	50*		
		EN2-	48*		
		EN3-	46*		
		EN4-	44*		
		EN5-	42*		
		EN6-	40*		
		EN7-	38*		
		EN8-	36*		

Table 3-2. Backplane Signal Distribution (Continued)

MC BACKPLANE SIGNAL MNEMONICS	MCI BUS CONNECTORS J10 & J11 except as noted	FUNCTION CARD BACKPLANE SIGNAL MNEMONICS	FUNCTION CARD BACKPLANE CONNECTORS P1	P2	P3
MFIN-	30*				
		FINT1-	49 !		
		FINT2-	47 !		
		FINT3-	45 !		
		FINT4-	43 !		
		FINT5-	41 !		
		FINT6-	39 !		
		FINT7-	37 !		
		FINT8-	35 !		
		RA1-		31*	
		RA2-		32*	
		RA3-		33*	
		RA4-		34*	
		RA5-		35*	
		RA6-		36*	
		RA7-		37*	
		RA8		38*	
MRIM-	38!	RIM-		43*	
MRESP-	29*	RESP-		21!	
MSWT-	40!	SWT-		23*	
MSYN-	5!	SYN-		47*	
MTMHZ	47!	TMHZ+		5*	
MTMHZR	48!				
MWRT-	39!	WRT-		41*	
MXCUT-	49!	XCUT-		17*	
MTST-	9!				
MIEX-	43!	IEX-		13*	
		KCOM		3,4,6 8,10	

Table 3-2. Backplane Signal Distribution (Continued)

MC BACKPLANE SIGNAL MNEMONICS	MCI BUS CONNECTORS	FUNCTION CARD BACKPLANE SIGNAL MNEMONICS	FUNCTION CARD BACKPLANE CONNECTORS		
	J10 & J11 except as noted		P1	P2	P3
25 kHz line	J12-1, J13-1				
25 kHz Com	J12-2, J13-2				
25 kHz SHLD	J12-3, J13-3	SHLD	1,2*		
9V ph1			7,8*		
9V ph2			9,10*		
17V ph1			5,6*		
17V ph2			11,12*		
17V C.T.			13-16*		
21V ph1			17,18*		
21V ph2			23,24*		
21V C.T.			19-22*		
21V C.T.			25-28*		

NOTES:
1. No footnote sign denotes bidirectional signal.
2. * Denotes signal source (from BIF).
3. (!) denotes signal destination (into BIF).

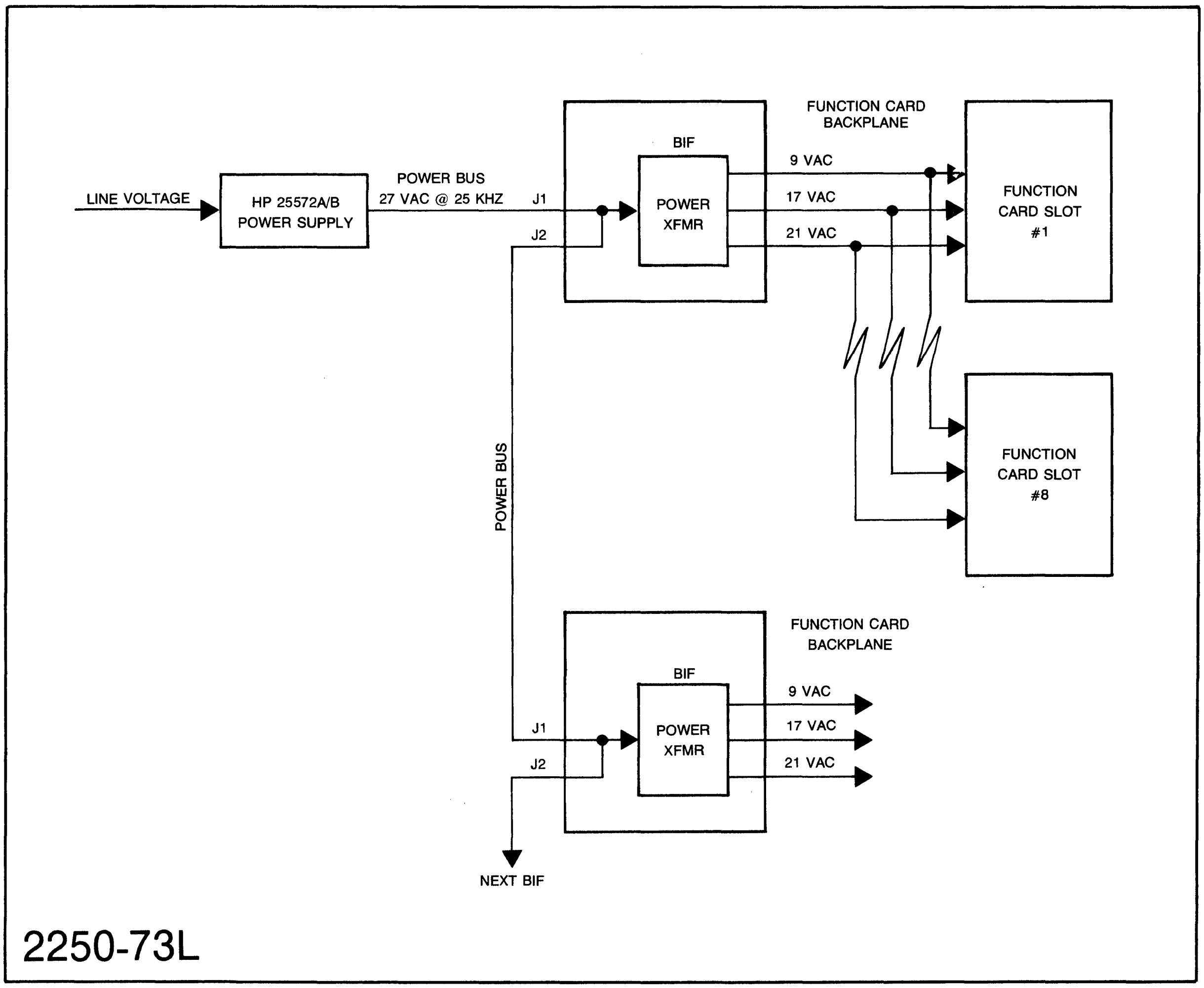


Figure 3-9. Power Distribution Diagram

3.7.1 Analog Function Cards

Sections IV through VIII provide a physical description, specifications, functional description, and calibration instructions for the analog function cards.

The analog input and output cards that are available are listed in table 3-3. In addition to their official names, the cards also are referred to by acronyms, that is, the Low-Level Mutiplexer card is referred to as the LLMUX and the Relay Multiplexer card is referred to as the RLYMUX, etc. The acronyms are parenthesized in table 3-3.

3.7.1.1 Analog Input Cards

The analog multiplexer cards provide input channel expansion for the HP 25501A 16-Channel High-Speed Analog Input (ADC) card. A single ADC card can support up to seven multiplexer cards, thereby providing up to 240 analog input channels to an HP 2250.

The multiplexer cards, some with programmable gain amplifiers along with the autoranging capability of the ADC card, can measure a wide dynamic range of voltages. For instance, inputs as low as 1.56 microvolts and as high as 100 volts can be measured by the LLMUX and the RLYMUX, respectively. High common-mode capability is also provided by the RLYMUX.

3.7.1.2 Analog Output Cards

Analog output voltages and currents are provided by the HP 25510A 4-Channel Voltage/Current Analog Output card. The analog output card has electrically isolated outputs of -10.240 volts to +10.235 volts at 20 mA, maximum.

Table 3-3. Analog Function Cards

INPUT CARDS	DESCRIPTION
HP 25501A	16-Channel High-Speed Analog Input Card (ADC)
HP 25502A	32-Channel High-Level Multiplexer Card (HLMUX)
HP 25503A	32-Channel Low-Level Multiplexer Card (LLMUX)
HP 25504A	16-Channel Relay Multiplexer Card (RLYMUX)

3.7.1.3 Input Signal Conditioning

Analog input signal conditioning includes low-pass filtering, and current-loop termination. Low-pass filtering is useful for reducing the amplitudes of unwanted frequencies such as 60 or 120 Hertz. Current-loop termination resistors change the inputs from current sources to voltages that can be processed by the ADC card amplifiers.

Signal conditioning for the HLMUX and the LLMUX is provided by Signal Conditioning Modules (SCMs) which are small printed circuit boards that plug onto the HLMUX and LLMUX cards. The SCMs are optional and must be ordered separately.

Information concerning the SCMs is provided in Section XIV of this manual.

3.7.1.4 HLMUX and LLMUX Signal Conditioning Modules

A selection guide of SCMs versus analog input function cards is provided in table 3-4. The specifications, component diagram, and schematic for HP 25540-Series SCMs is provided in table 3-5. Note that the SCMs are used only by the LLMUX and HLMUX cards.

Table 3-4. Analog Input Card Signal Conditioning Modules

ANALOG CARD	SCM	DESCRIPTION
HP 25501A	None	ADC Card (signal conditioning resistors and capacitors can be added to the card).
HP 25502A	A,B,C,D*	HLMUX Card
HP 25503A	A,B,C,D*	LLMUX Card
HP 25504A	None	RLYMUX Card

* A,B,C and D are the SCM suffixes relating to the SCM NUMBER listed below.

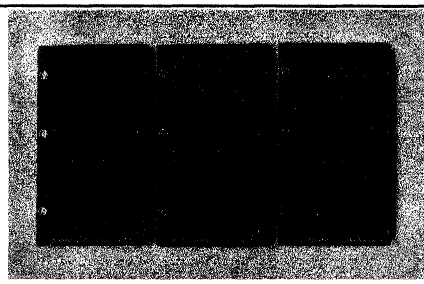
SCM NUMBER	CHANNELS PER SCM	DESCRIPTION
25540A	8	Blank (User supplies components).
25540B	8	Passive Filter Network Capacitors.
25540C	8	Current-Loop Resistors
25540D	8	Current-Loop Resistors and Filter Capacitors

Table 3-5. SCM Data

Specifications

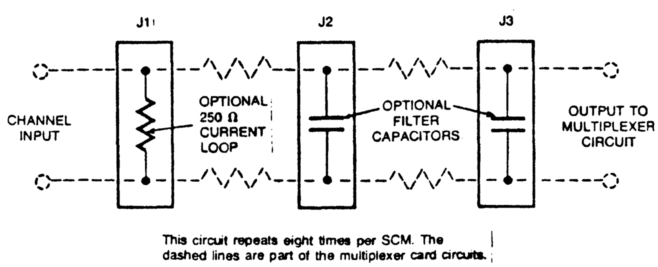
Current-loop termination Resistance:	250 ohms +/- 0.025%
Temperature coefficient:	10 ppm per degree Centigrade.
Filter pole frequencies, Minimum:	52 Hz and 7.5 Hz

Component Location Diagram



2250-114H

HP 25540-Series Schematic Diagram



3.7.1.5 Power Supply Circuits

Each analog card has its own power supply circuit which rectify and regulate a 25 kHz sine-wave voltage from the BIF into +12 Vdc for use by the analog card. Also received from the BIF is a +12 Vdc signal which is used by the analog cards to keep their backplane drivers disabled in the event that their own +12 Vdc power supplies fail.

3.7.1.6 Register Addressing

All input and output channels, channel gains, and certain system functions on the analog cards have associated addressable read/write registers which, when written to or read from, perform a particular operation. For instance, if the Card ID register of an analog card is programed to be read, the Card ID Register will return a two digit code (the last two digits of the card model number) indicating the type of card occupying the addressed slot. A write to an Output Channel Register on the Analog Output Card will cause the card to output an analog voltage/current from the associated output channel.

There are 256 registers defined for the digital and analog cards, of which only a few have meaning for the analog cards as indicated in table 3-6. Registers 254 and 255 are used by the firmware and are not shown in the table. Also, the status and interrupt registers are not shown, as they are not used by the analog cards. If read, all four of these registers should return zeros.

Each address shown in the table is dedicated to a particular register. For example, the Gain Register Addresses 193 through 208 for the HP 25501A card relate to the card's 16 input channels, 1 through 16, respectively. In operation, writing to address 193 will store the gain value to be used by channel 1, and writing to address 194 will store the gain value to be used by channel 2, etc.

Table 3-6. Analog Card Addressable Registers

Analog Cards	Read Registers				
	Gain Register	Data Register	Zero Register	Card ID Register	Card Configuration Register
	Address	Address	Address	Address	Address
HP 25501A	193-208	1-16	129-144	253	249
HP 25502A	193-224	1-32	129-160	253	249
HP 25503A	193-224	1-32	129-160	253	249
HP 25504A	193-208	1-16	129-144	253	249
HP 25510A				253	249

Analog Cards	Write Registers		
	Gain Register	Output Channels 1-4 Registers	Card Configuration Register
	Address	Address	Address
HP 25501A	193-208		249
HP 25502A	193-224		249
HP 25503A	193-224		249
HP 25504A	193-208		249
HP 25510A		65 through 68	

This same relationship of addresses versus channel numbers applies to the Data Registers. Reading the Data Registers will cause a data transfer to the processor unit. However, the Data Registers are double-word registers containing the analog-to-digital-converter (ADC) output of the HP 25501A card in the first word and the system gain in the second word.

Zero Register Addresses 129 through 160 (channels 1-32) provide a zero input to the card when read. The Zero Registers are also double-word registers and contain the same information as described above for the Data Registers. The operation of the Zero Registers is described in this section in the paragraph "Zero Registers."

The HP 25510A 4-Channel Voltage/Current Analog Output card, addresses 65 through 68, respectively control its four output registers, channels 1 through 4. When one of these addresses is written to, the selected channel outputs the programmed analog value.

The Card ID and Card Configuration Registers are standard system registers. When the Card ID Register Address 253 is read, the card ID, which is a hard-wired code on the card, is sent to the processor unit. The code from the Card ID Register contains the last two digits of the card model number. For example, the code is 01 for the HP 25501A and 02 for the HP 25502A. The Card ID Register can also accommodate a code for card revisions and options when they occur. Hence, until a revision occurs the card will only return the last two digits of the card model number.

For the HP 25502A, HP 25503A, and HP 25504A, the Card Configuration Register Address 249, when read, reports the status of the Open Sensor Detect Circuit as to whether it is activated or not. Open Sensor Detection is explained in the paragraph, "Open Sensor Detection", below. When written to, the Card Configuration Register either activates or deactivates the Open Sensor Detect circuit unless the same state is requested. That is, if the Open Sensor Detect is already activated and is then programmed to be activated again, no change will occur. The same is true for the deactivated state.

The Card Configuration Register, Address 249, for the HP 25510A Analog Output Card can only be read. It contains information for each channel as to whether the channel is set for a unipolar/bipolar voltage output or for a current output.

The Card Configuration Register, Address 249, for the HP 25501A card, contains the "Global Autoranging" bit. When Global Autoranging is programmed, the Least Significant Bit (LSB) of the Card Configuration Register is set to a "one". When a Zero Register is read, the "high" LSB causes autoranging to occur which overrides the programmed gain of the ADC card's Programmable Gain Amplifier.

3.7.1.7 Open Sensor Detect

The HP 25502, 25503, and 25504 cards each contain an Open Sensor Detect circuit. This circuit can detect an open circuit in one of the input channels. It is turned on or off by setting or clearing bit 7 of the card configuration register (register 249). When the Open Sensor Detect is on, the card puts out a small current (1 to 6 microamperes) to check for an open circuit. If the circuit is open (an input line is broken or unplugged), the current feeding into the high resistance will drive the voltage to the overrange state and give a positive full-scale voltage reading. This will happen on any gain range of 1 or greater. The Open Sensor Detect circuit does not work for gains of less than 1.

An overrange condition produces the same results as an open circuit. That is, if an overrange input voltage is applied, a full-scale reading occurs. To determine whether an overrange condition or an open circuit is causing the full-scale reading, turn off Open Sensor Detect and take another reading. If the input circuit is open, the voltage reading will drop to a low noise level; if the circuit is closed and an overrange voltage is present, the reading will remain at full scale.

Another condition that can cause a full-scale reading is a high resistance in the input circuit. When the detection current is applied to such a resistance, the voltage induced in the circuit can give a full-scale reading, especially in the higher gain ranges. You can distinguish this situation from an open circuit by reducing the gain and taking a reading: if the circuit is closed, the voltage reading will be less than full scale in the lower gain ranges; if it is open, the reading will remain at full scale in all gain ranges of 1 or greater.

If the voltage induced by the detection current contaminates your reading excessively, you can turn on the Open Sensor Detect circuit to check for an open circuit, and then turn it off to make the actual reading.

When you use open sensor detection, you must allow time for the detection current to charge up any capacitance in the input of the channel you are testing. To do this, turn on Open Sensor Detect, take a reading, wait for the capacitance to charge up, and then take another reading; the second reading will be valid. Note that the two readings must be taken in the same command sequence. That sequence would have the general form:

```
CPACE (delay) WPACE BLOCK AI (slot,channel,2)
```

where "delay" is the time interval between the two readings. In most cases, one second of delay will yield good results; it may need to be greater, however, if the capacitance in the input circuit is very high.

3.7.1.8 Zero Registers

The offset voltages of the multiplexer cards and the HP 25510A card may be checked by reading their ZERO registers. Addressing a ZERO register connects a short across the input of the card's Amplifier. The resulting offset voltage is processed by the HP 25501A ADC card in the same manner as for a normal analog input voltage as described in the individual function card sections.

The HLMUX and LLMUX cards each have 32 Zero Registers, one for each of their 32 input channels. The ADC and RLYMUX cards have sixteen Zero Registers. Even though there is a Zero Register for each channel, only one need be read to obtain the offset voltage for each gain range. When the Zero Register of a multiplexer card is read its offset voltage is sent to the input of the ADC card. As an offset voltage from a multiplexer card is processed by the ADC card it is cumulatively added to that developed by the ADC card. The combined offset voltage is then sent to the processor unit as the total analog system offset voltage. According to the programmed command, the offset voltage may be used to give corrected analog voltage readings or non-corrected readings. For improved accuracy involving analog voltage readings to be corrected, the offset value should be read for each range to be used.

3.7.2 Digital Function Cards

Sections IX through XII cover HP 2250 digital function cards and provide physical descriptions, specifications, and functional descriptions for each card.

The digital input and output capability of the HP 2250 is provided by the digital function cards. The digital input and output cards that are available with the HP 2250 are listed in table 3-7.

3.7.2.1 Digital Input Cards

Digital inputs are provided by the HP 25511A 32-Point Digital Input and the HP 25516A 16-Point Multifunction cards.

The input functions of the HP 25511A and HP 25516A cards are basically the same except that the multifunction card (HP 25516A) includes event counting which is not available in the 32-point digital input card (HP 25511A).

The inputs of the cards are divided into 16-point fields, and each field has an external strobe input. The external strobe is optionally used to synchronize the desired input data, and to delay the time between card setup and data input so the points of several cards can be input simultaneously.

The inputs offer different characteristics through the use of signal conditioning modules (SCMs) which you select and attach to the cards during installation. SCMs for the input-point fields accomodat four points each, and they may be mixed on a card to take care of a variety of applications with one card.

3.7.2.2 Digital Output Cards

Binary solid-state digital outputs are provided by the HP 25513A 32-Point Digital Output card and the HP 25516A 16-Point Multifunction card. Relay switching outputs are provided by the HP 25514A 16-Point Relay Output card.

The outputs are divided into 16-bit fields on the 32-point digital output (HP 25513A), 16-point digital multifunction (HP 25516A) and 16-point relay output (HP 25514A) cards. The digital output and relay output cards have an external strobe input to synchronize changes in output states, and to coordinate the setup of more than one card.

Table 3-7. HP 2250 Digital Function Cards

PRODUCT	DESCRIPTION
25511A	32-Point Digital Input
25513A	32-Point Digital Output
25514A	16-Point Relay Output
25516A	16-Point Digital Multifunction

3.7.2.3 Digital Function Card Signal Conditioning

Signal conditioning modules are used with all digital function cards. They are inserted in series with the I/O circuits and the I/O connectors to which the field wiring attaches.

Digital SCMs provide various options on isolation of the field wiring, input signal range, and ac or dc signals. For the relay output card, arc suppression SCMs provide options for various voltage ranges and ac or dc selection.

Table 3-8 contains a digital SCM selection guide.

3.7.2.4 Digital Function Card Register Addressing

All input and output points, point sense conditions, event counting, and certain system functions on digital function cards have associated addressable 16-bit read/write registers. The registers when written to or read from, perform a particular operation according to the program request.

The registers defined for the digital cards are listed in table 3-9.

Each address shown in the table is dedicated to a particular register. For example, the Point Register Addresses 1 through 32 for the HP 25511A relate to the input points 1 through 32. In operation, reading from address 1 will return the state (value) of the input of Point 1.

Table 3-8. Digital SCM Selection Guide

PRODUCT REFERENCE		
FUNCTION CARD	CROSS REFERENCE SCM NUMBER	DESCRIPTION
25511A	1 & 2*, 3 & 4	32-Point Digital Input.
25513A	1 & 2*, 5,6,7	
25514A	1 & 2*, 8	16-Channel Relay Output.
25516A	1 & 2*, 3,4,5 6,7	32-Point Multifunction

* Single Channel SCM for External Strobe Input

SCM CROSS REFERENCE GUIDE			
SCM NO.	PRODUCT NO.	POINTS	DESCRIPTION
1	25531-Series 25531B 25531C 25531D 25531E 25531K 25531L	1	Non-Isolated Digital Input. 5 VDC Range. 12 VDC Range. 24 VDC Range. 48 VDC Range. 5 VDC Range,Sink Inputs. 12 VDC Range, Sink Inputs.

Table 3-8. Digital SCM Selection Guide (Continued)

SCM CROSS REFERENCE GUIDE			
SCM NO.	PRODUCT NO.	POINTS	DESCRIPTION
2	25533-Series	1	Isolated Digital Input.
	25533B		5 VDC Range.
	25533C		12 VDC Range.
	25533D		24 VDC (16 VAC) Range.
	25533E		48 VDC Range.
	25533F		72 VDC Range.
	25533G		120 VDC (72VAC) Range.
	25533H		115 VAC Range.
	25533J		230 VAC Range.
3	25535-Series	4	Non-Isolated Digital Input.
	25535B		5 VDC Range.
	25535C		12 VDC Range.
	25535D		24 VDC Range.
	25535E		48 VDC Range.
	25535K		5 VDC Range, Sink Inputs.
	25535L		12 VDC Range, Sink Inputs.
4	25537-Series	4	Isolated Digital Input.
	25537P		5 VDC Range.
	25537Q		12 VDC Range.
	25537R		24 VDC (16VAC) Range.
	25537S		48 VDC Range.
	25537T		78 VDC Range.
	25537U		120 VDC (72VAC) Range.
	25537V		115 VAC Range.
	25537W		230 VAC Range.
5	25543N	4	Isolated Digital Output, VMOS Solid-State Circuit.
6	25544-Series	4	Non-Isolated Digital Output
	25544A		Open Drain Circuit.
	25544B		5 VDC Range.
	25544C		12 VDC Range.
7	25545P	2	Solid-State Relay Output (Reduces usable points by 2).

Table 3-8. Digital SCM Selection Guide (Continued)

SCM SELECTION GUIDE			
SCM NO.	PRODUCT NO.	POINTS	DESCRIPTION
8	25539-Series 25539A 25539E 25539G 25539H 25539J	4	Arc Suppression Circuits. For user added components. 0 to 30 VDC Range. 24 VAC Range. 115 VAC Range. 230 VAC Range.

Table 3-9. Digital Cards Addressable Registers

FUNCTION CARD	REGISTER (DECIMAL)	DATA
25511A 25516A	1-16	Input Points 1-16 (Field 1 Current State) where Point 1=Reg. 1 (Bit 0),Pt. 2=Reg. 2 (Bit 0),etc.
25511A	17-32	Input Points 17-32 (Field 2 Current State) where Point 17= Reg. 17 (Bit 0),Point 18= Reg. 18 (Bit 0), etc.
25513A 25514A 25516A	65-80	Output Points 1-16 (Field 1 Current State) where Point 1=Reg. 65, Point 2= Reg. 66, etc.
25513A	81-96	Output Points 17-32 (Field 2 Current State) where Point 17=Reg. 81, Point 18= Reg. 82, etc.
25516A	129-144	Event Counter (16 Registers for 16 Input Points where Counter 1=Reg. 129, Cntr. 2=Reg. 130,etc.
25516A	145-160	Counter Preset (Preset No. for Event Counters) where Preset 1=Reg. 145, Preset 2=Reg. 146,etc.
25511A 25516A	161	Input Field 1 of Points 1-16.*
25511A	162	Input Field 2 of Points 17-32.*
25513A 25514A 25516A	177	Output Field 1 of Points 1-16*
25513A	178	Output Field 2 of Points 17-32*
25511A 25516A	209	Field 1 Sense (Direction of Change for Event).*
25511A 25516A	225	Unmask of Field 1.*
25511A	210	Field 2 Sense (Direction of Change for Event).*
25511A 25516A	211	Override Field 1 (Allows both Directions of Change for Events.*

Table 3-9. Digital Cards Addressable Registers (Continued)

FUNCTION CARD	REGISTER (DECIMAL)	DATA
25511A	226	Unmask of Field 2.*
25511A	212	Override Field 2 (Allows both Directions of Change for Events.*
25516A	193	Counter Rollover.
25511A 25516A	241	Interrupt of Field 1 (Record of Event Interrupts). Resets on Read.*
25511A	242	Interrupt of Field 2 (Record of Event Interrupts). Resets on Read.*
ALL	249	Card Configuration. Bit 0 =Field 1 Ext Strobe Mode, Bit 1= Field 2 Ext Strobe Mode. (Ext. Strobe required when set.) Bit 8=Field 1 Strobe Polarity,Bit 9=Field 2 Strobe Polarity. (Latches on rising edge when set.)
ALL	251	Card Status. Busy:Bit 15 (Card Busy When Set and Will Not Accept Commands). Strobe Wait:Bit 0 Field 1, Bit 1 Field 2 (Card Waiting for Strobe When Set).
ALL	253	Card Identification: Decimal 11=HP 25511A. Decimal 13=HP 25513A. Decimal 14=HP 25514A. Decimal 16=HP 25516A.

*Cards with a maximum of 16 points have one field (Field 1). Field register bits correspond to Points of Field, as follows:

For Field 1, Bit 0 = Point 1
Bit 1 = Point 2, etc.

For Field 2, Bit 0 = Point 17
Bit 1 = Point 18, etc.

The functions of the registers are defined in table 3-9 and explained further in the functional descriptions of the individual cards (Sections VI through XII of this manual). Operation of the Card Status Register (Register 251) is further described below to point out differences in applying an External Strobe for digital input and digital output cards (providing that the corresponding External Strobe bit in the Configuration Register is set).

Bits 0 and 1 of Register 251 are "Strobe Wait Bits," where Bit 0 is for Field 1 and Bit 1 is for Field 2. When the bit associated with a field is set (true) the card will wait for further operation on that field with the following meanings:

a. Output data has not been strobed to the second-rank output drivers; i.e. the most recent programmed change has not appeared at the output pins. An External Strobe will move data to the output pins and clear the bit.

b. Input data has not been latched since the last time there was a "read" from the card's Input Point Register. An External Strobe will latch new data and clear the bit.

3.7.3 FUNCTION CARD CABLING

In the next several paragraphs we will discuss the cables that connect the function cards to the field wiring. Figure 3-10 shows a typical cable and field wiring assembly.

One end of each function card cable has a connector that attaches to the function card; the other end of the cable attaches to the field wiring, as explained below.

Connectors on the function card end of the cable may be:

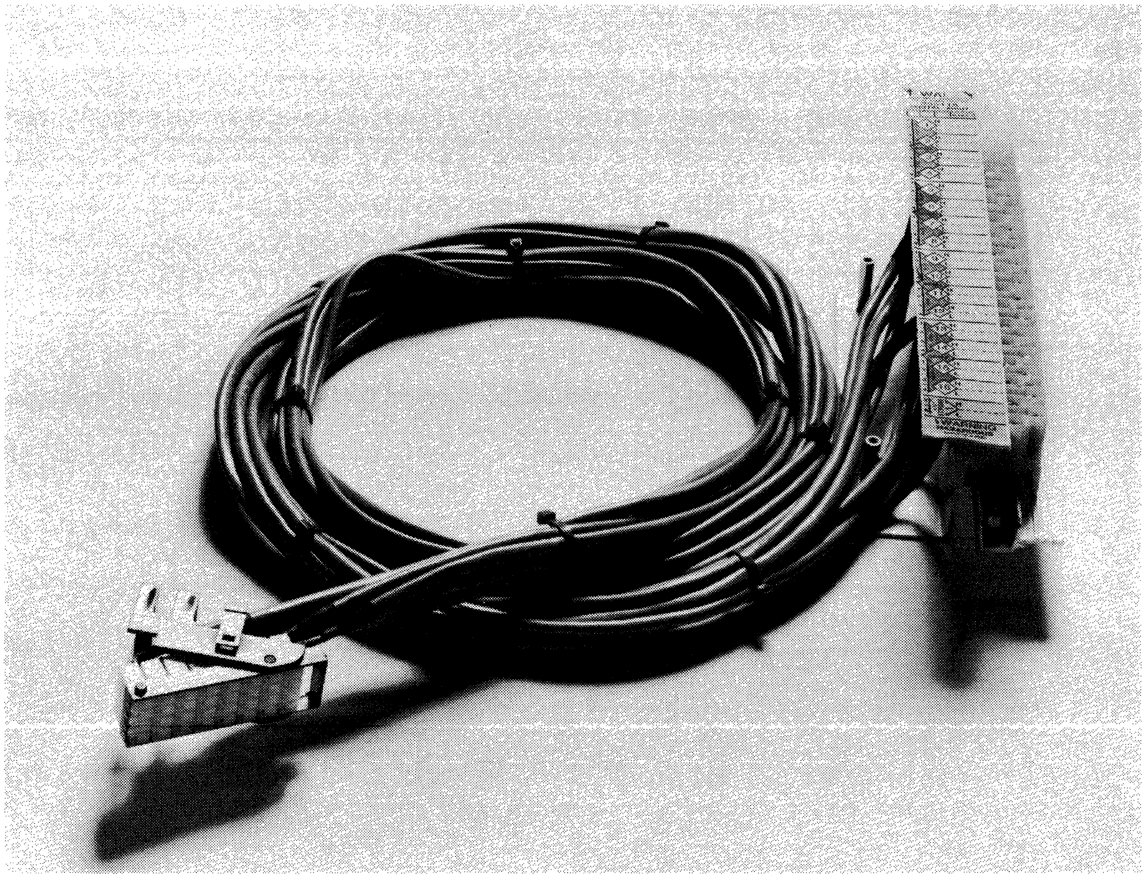
1) Digital function card connectors. These connectors are used for all digital function cards.

2) Analog function card connectors. These connectors are used for all analog function cards except the HP 25504 Relay Multiplexer (RLYMUX) card.

3) RLYMUX card connectors. These connectors are used only for the HP 25504 RLYMUX card. (These special connectors are used because of the high common mode voltages -- up to 350 volts or more -- that may be connected to the RLYMUX card.)

Connectors on the field wiring end of the cable provide for attachment to your sensors and actuators. They may be:

1) Screw terminations. (This is the type shown in figure 3-10.) The screw terminations allow you to connect wire as heavy as 14 AWG using a screwdriver.



52A-0629

Figure 3-10. Cabling and Field Wiring Assembly

2) Unterminated cables. Cables with no terminations allow you use your own connectors.

3) Thermocouple Reference Connector (TRC). The TRC allows direct connection of thermocouple wiring and provides an accurate reference junction for thermocouple measurements. The TRC is described in Section XIII of this manual. The TRC is for use with only the HP 25503 Low Level Multiplexer (LLMUX) card or the HP 25504 RLYMUX card.

Table 3-10 shows the combinations of cables and connectors that are available.

Table 3-10. Function card cables

Product Number	Connectors	
	Card	Field Wiring
25550A	digital	screw terminations
25550B	digital	unterminated
25551A	analog*	screw terminations
25551B	analog*	unterminated
25551C	RLYMUX	screw terminations
25551D	RLYMUX	unterminated
25594A	LLMUX	thermocouple reference
25594B	RLYMUX	thermocouple reference

* except HP 25504 RLYMUX card

The descriptions of the function cards in Sections IV through XII of this manual give the pin assignments of the connectors on the function cards. Figure 3-11 shows the numbering of the connector modules and pins.

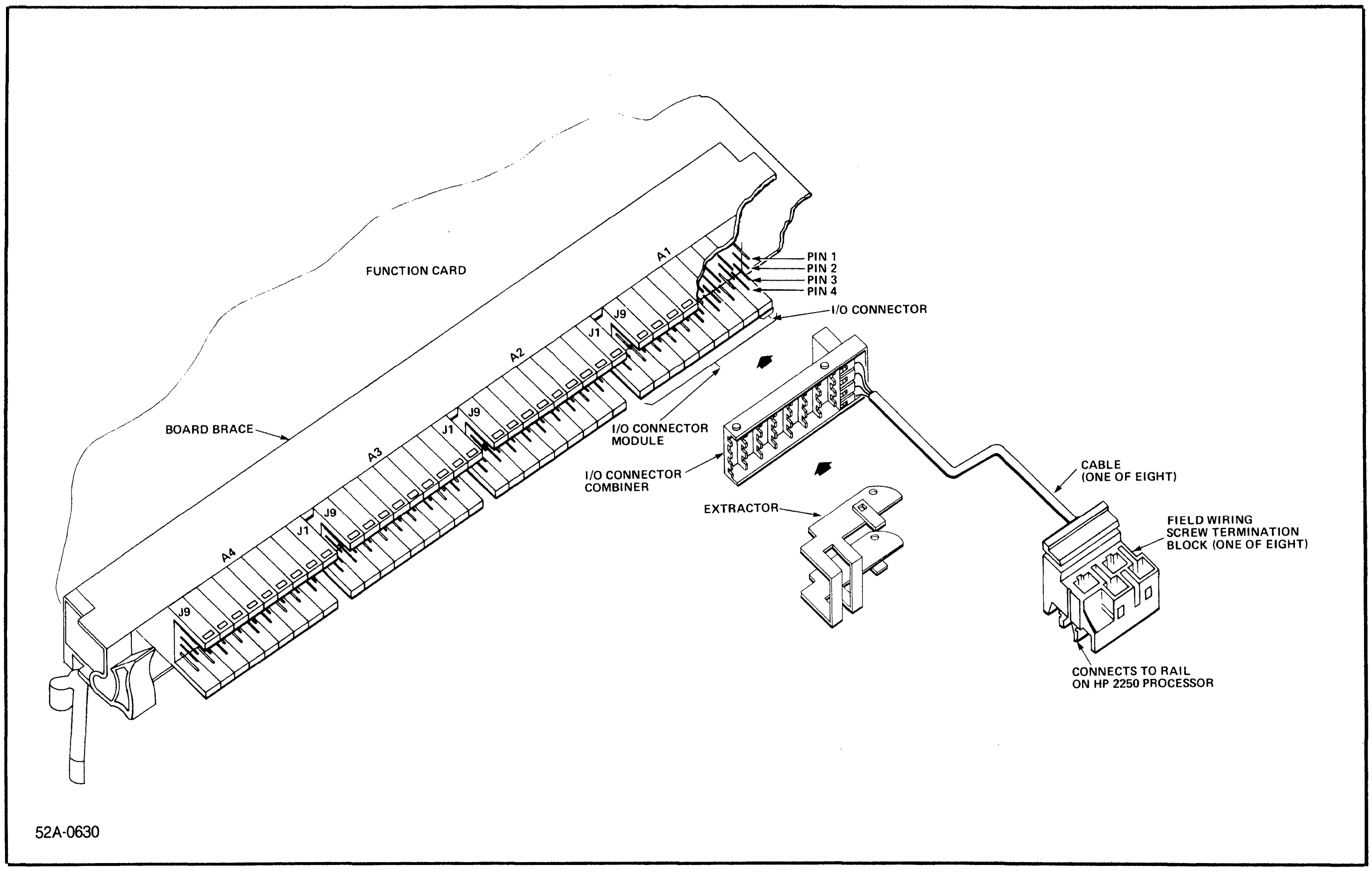


Figure 3-11. Connector Modules and Cable Assembly

Section IV
HP 25501A 16-Channel High-Speed Analog Input

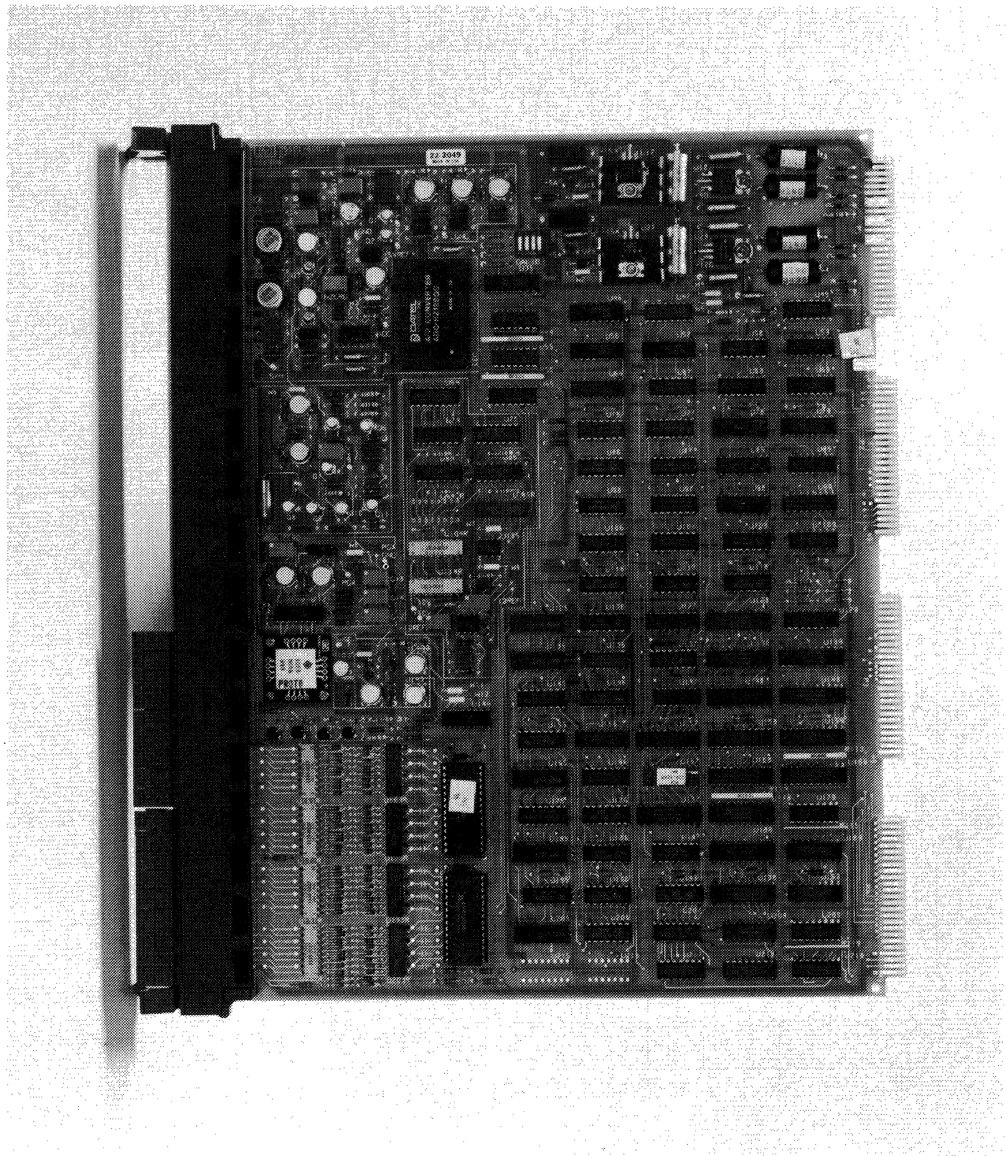
4.1 INTRODUCTION

This section provides information for the HP 25501A 16-Channel High-Speed Analog Input card. Included are a functional description, specifications, and calibration instructions. Installation information for the card is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

4.2 DESCRIPTION

The HP25501A, shown in figure 4-1, provides the basic analog input capability for the HP 2250 Measurement and Control Processor system. Its combination of high speed (50 kHz) analog-to-digital converter, sample and hold amplifier, and programmable gain amplifier (gains of 1, 2, 4, 8, or autorange) provides the ability to process a wide variety of analog input signals. The card also features 14-bit resolution, overvoltage protection, automatic zeroing, and provision for user-installed input signal conditioning.

The HP 25501A card has 16 addressable input channels which can be expanded up to a maximum of 496 input channels by the installation of up to 15 HP 25502A 32-Channel High-Level Multiplexer cards and/or HP 25503A 32-Channel Low-Level Multiplexer cards.



2250-74H

Figure 4-1. HP 25501A 16-Channel High-Speed Analog Input Card

4.3 SPECIFICATIONS

Specifications for the ADC card are provided in table 4-1.

4.4 INPUT SIGNAL CONDITIONING

Plated-through holes are provided on the card for the installation of user-supplied input filter capacitors and current-loop termination resistors. There are 32 plated-through holes for capacitors and 32 for resistors allowing one capacitor and one resistor to be connected across each differential input channel.

Resistors with a value of 250 ohms +/- 0.02 percent should be used for current-loop termination. The capacitor values to be selected will vary depending on the desired cut-off frequency needed for the low-pass filter. The following information will help in selecting the desired capacitor values.

Each input circuit of the card has two fixed resistors giving an effective resistance of 2400 ohms for use in the filter circuit. The 2400 ohm value, along with the desired frequency, should be used in the following formula to calculate the appropriate capacitor value. The value computed will set the low-pass filter to the 3-db point with a 6-db-per-octave rolloff at the designated frequency.

C = 1/(2*pi*R*F)

where

C is the value of the capacitor to be determined, in farads
R is the 2400-ohm resistance value
F is the frequency, in hertz

Table 4-1. HP 25501A Specifications

FEATURES

- 14-bit resolution
- 50,000 samples/second
- 16 differential input channels
- Programmable gain amplifier
- Autoranging at the full 50,000 samples/second
- Auto zero
- Input protection on all 16 differential input channels
- Accurate to within 0.08% over 0 to 65 degrees C

APPLICATIONS

Conversion of analog signals from transducers, transmitters, temperature sensors, etc., to digital form, with high speed and high resolution.

PROGRAMMING INFORMATION

AI command:	Return voltage from specified channel in millivolts
AIR command:	Return voltage in HP 1000 real format
AID command:	Return voltage in double integer format
AIC command:	Return data from channel in raw card format
GAIN command:	Set gain (range) on a specified channel
RGAIN command:	Read gain (range) on a specified channel
AON command:	Autorange on
AOFF command:	Autorange off
CLB command:	Perform an auto-zero cycle
RANGE command:	Set analog range

Table 4-1. HP 25501A Specifications (Continued)

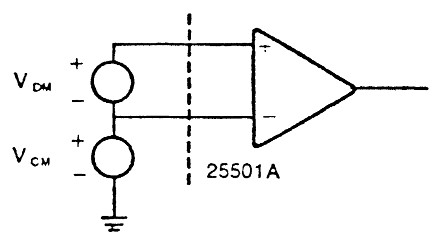
ELECTRICAL CHARACTERISTICS

INPUT RANGES AND RESOLUTIONS

Input Channel Span	Input Channel Range	Resolution	PGA Gain
20V	+/- 10V	1.25mV	1
10V	+/- 5V	625uV	2
5V	+/- 2.5V	312uV	4
2.5V	+/- 1.25V	156uV	8

MAXIMUM INPUT VOLTAGES FOR RATED ACCURACY

Maximum differential voltage + maximum common node voltage must be less than or equal to +/- 10 volts



Example: On the +/- 2.5 volt range, the maximum differential input allowed is +/- 2.5V, therefore:

$$V_{CM} = 10 - 2.5 = 7.5 \text{ volts}$$

SOURCE IMPEDANCE AND IMBALANCE; RETURN IMPEDANCE

Maximum source impedance for rated accuracy: 1K ohm

Maximum source imbalance for rated accuracy: 1K ohm

Maximum return impedance for rated accuracy: 10K ohm

Table 4-1. HP 25501A Specifications (Continued)

INPUT IMPEDANCE

Power On: >= 10 megohm shunted by <= 80 pF

Power Off: 1K ohm +/- 10% to ground
2K ohm +/- 20% to any other signal input line

INPUT OVERLOAD PROTECTION

No damage will occur below the following levels:

Power On Steady State: Up to +/- 25 volts on any ONE input signal line to ground, or to any other ONE signal input line.

Derate by 1 volt for each additional overloaded signal input line.

Example: What is the maximum simultaneous allowable overload on 4 input channels?

There are 2 input lines per channel, therefore,

Max overload voltage per line =

25 - (4 x 2 x 1) = 17 volts

Transient: +/- 50 volts on any one input signal line to ground or to any other one signal input line, for a maximum of 10 seconds.

Power Off Steady State: Up to +/- 15 volts on any ONE input signal line to ground, or to any other ONE input signal line.

Up to +/- 12.5 volts on all input signal lines simultaneously.

Table 4-1. HP 25501A Specifications (Continued)

COMMON MODE REJECTION AND CROSSTALK

Common Mode Rejection:

Source Imbalance	Frequency	Common Mode Rejection	uV of Error Referred to Input Per 1 Volt of Common Mode
0 ohm	DC to 1 kHz	86	50
	DC to 5 kHz	76	158
	DC to 10 kHz	70	316
1K ohm	DC to 50 Hz	80	100
	DC to 100 Hz	74	200
	DC to 500 Hz	60	1000
	DC to 5 Hz	54	2 mV

AC Crosstalk:

Frequency	db	mV of error referred to input per 1 volt of signal on adjacent channel
DC to 2.5 kHz	96	16
5 kHz	90	32
10 kHz	84	64
25 kHz	72	250

Overload Crosstalk:

Readings on channels adjacent to overloaded channel will meet AC crosstalk specification for overload voltages within the input overload specification.

Overload Recovery Time:

Readings within rated accuracy within 1 msec after removal of maximum overload, or after changing channels from overloaded to non-overloaded channel.

Table 4-1. HP 25501A Specifications (Continued)

ACCURACY

Static Accuracy:

(DC frequency inputs), without auto-zero cycle, at 25 degrees C

Input Channel Range	Accuracy Referred To Input (+/- 1/2 LSB)	
	% of Full Scale Referred to Input	Volts Referred to Input
+/- 10	+/- 0.04	+/- 4 mV
+/- 5	+/- 0.04	+/- 2 mV
+/- 2.5	+/- 0.05	+/- 1.25 mV
+/- 1.25	+/- 0.06	+/- 750 uV

AC Accuracy:

Bandwidth:

Full-Power Bandwidth

Input Channel Range	Bandwidth
+/- 10	10 kHz
+/- 5	10 kHz
+/- 2.5	10 kHz
+/- 1.25	10 kHz

Table 4-1. HP 25501A Specifications (Continued)

Small Signal Bandwidth

Input Channel Range	Bandwidth		
	0.1% Flatness	1% Flatness	-3db
+/- 10	10 kHz	45 kHz	300 kHz
+/- 5	10 kHz	45 kHz	300 kHz
+/- 2.5	10 kHz	30 kHz	200 kHz
+/- 1.25	10 kHz	20 kHz	125 kHz

NOISE

Input Channel Range	Effective uV RMS Referred to Input	uV Peak-to-Peak Referred to Input
+/- 10	625 mV	3.75 mV
+/- 5	312 mV	1.25 mV
+/- 2.5	156 mV	625 uV
+/- 1.25	78 uV	469 uV

SAMPLE AND HOLD

Aperture Time: < 50 nsec

SETTLING TIME

Output data within 2 LSBs of final value within one conversion time (20 usec) for any in-range combination of full-scale inputs and range changes.

Example: Channel 1 at +10 volts to channel 2 at -10 volts, or

Channel 6 at +10 volts on +/- 10 volt range to channel 11 at -1.25 volts on +/- 1.25 volt range

PACING CAPABILITY

To 50 kHz maximum, channel to channel or across channels, random or sequential sequencing.

Slower rates software selectable.

Table 4-1. HP 25501A Specifications (Continued)

AUTORANGING CAPABILITY

(Can be selected on a card or per-channel basis)

Autoranged Gain	Effective Input Range (+/- 2%)
1	+/- 10V
2	+/- 4V
4	+/- 2V
8	+/- 1V

Autoranging Time: No additional conversion time required for autoranging. Does not affect throughput.

PHYSICAL CHARACTERISTICS

Width: 28.91 cm (11.38 in.)

Depth: 34.8 cm (13.5 in.)

Height: 3.49 cm (1.38 in.)

Weight: 680 grams (1.5 lbs)

If current-loop termination is desired, installation of the user-supplied components can be made using the plated-through holes provided on the card.

The bottom two rows of holes are for connecting the current-loop resistors. The upper two rows are for connecting the low-pass filter capacitors. After the components are selected, install them by inserting their leads into the plated-through holes for the desired channels and solder them into place. All soldering and lead dressing should be performed by qualified personnel abiding by standard manufacturing soldering techniques and safety rules.

4.5 FUNCTIONAL DESCRIPTION

Figure 4-2 is a functional block diagram of the ADC showing the input/output buses and the major functions of the ADC card.

The primary purpose of the ADC card is to sample an analog input voltage, convert its value to a 14-bit digital word, and transfer it along with the system gain to the HP 12071A Measurement and Control Interface (MCI) card.

Up to 16 channels can be connected directly to the input connectors on the ADC card. Each input channel has an associated DATA register. An input channel is selected by addressing its associated DATA register.

The differential analog input voltage from the selected channel passes through a Multiplexer circuit and drives a Differential-to-Single-Ended Converter. The output of the Single-Ended Converter is applied to the input of a Programmable Gain Amplifier (PGA).

Each differential input channel on the ADC card has an associated GAIN register. At any time, you may program a GAIN register to change or read its contents. Each of these GAIN registers can be programmed to one of the following gain selections: 1, 2, 4, 8, or autoranging. When a reading is requested from a specific channel, the contents of the associated GAIN register automatically set the gain of the PGA to the programmed value or to autorange. The autoranging operation is described later in this section.

After amplification in the PGA, the analog voltage is sampled by a Sample and Hold Amplifier. When a Measurement Strobe occurs, the sample is stored. The stored voltage is then converted to a digital word by the ADC circuit. The 14-bit digital output word and the system gain value from the ADC card are sent to the MCI card, in response to a read from the selected DATA register.

4.5.1 Autoranging

In the autorange mode, the ADC card compares the value of the input voltage to an internal reference voltage, and then selects the highest gain it can use without overloading the ADC. At power turn on, the HP 2250 system sets the ADC card PGA to a gain of 1. The autorange mode is useful for measuring voltages of unknown amplitudes or for voltages of wide dynamic range.

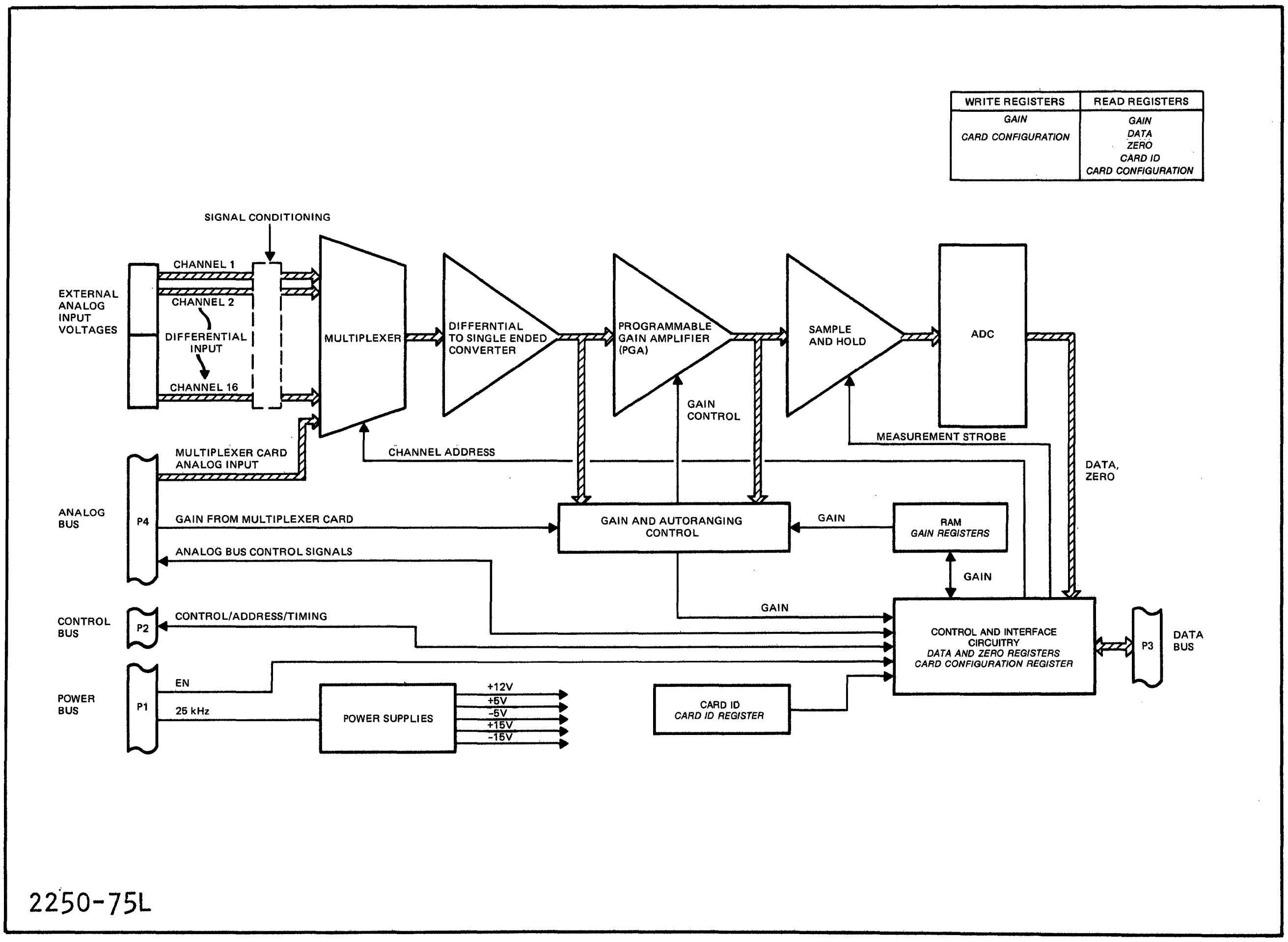


Figure 4-2. HP 25501A Functional Block Diagram

The nominal range switching point is at 80 percent of full scale. There is a slight hysteresis around the switching point, therefore multiple readings on a channel with an input value very close to the switching point will not repeatedly switch back and forth between ranges. The 80 percent switching point effectively reduces the resolution from a percent of maximum reading to 80 percent of that for a programmed gain mode.

4.6 REGISTER ASSIGNMENTS

Register assignments for the ADC card are shown in table 4-2.

The analog input cards (ADC and multiplexers) all have the same register assignments. The raw data returned from the card is in double word format. The register assignments allow for future expansion up to 48 channels per card.

To read the zero-reference voltage on a channel, read from the appropriate register on pages 9-11. Programming the gain for a channel is done by writing to the registers on pages 13-15.

The meaning of the configuration word of the analog input cards varies from card to card. For the ADC card, the following meanings apply:

Bit	Meaning
1	1 - Autorange all channels 0 - Use programed autorange bits

A read of the card status register always will return 0.

TABLE 4-2. ANALOG INPUT REGISTER ASSIGNMENTS

	PAGE 1		PAGE 2		PAGE 3		PAGE 4	
	word 1	word 2	word 1	word 2	word 1	word 2	word 1	word 2
	1st	2nd	1st	2nd	1st	2nd		
1	DATA1	GAIN1	DATA17	GAIN17	DATA33	GAIN33		
2	DATA2	GAIN2	DATA18	GAIN18	DATA34	GAIN34		
3	DATA3	GAIN3	DATA19	GAIN19	DATA35	GAIN35		
4	DATA4	GAIN4	DATA20	GAIN20	DATA36	GAIN36		
5	DATA5	GAIN5	DATA21	GAIN21	DATA37	GAIN37		
6	DATA6	GAIN6	DATA22	GAIN22	DATA38	GAIN38		
7	DATA7	GAIN7	DATA23	GAIN23	DATA39	GAIN39		
8	DATA8	GAIN8	DATA24	GAIN24	DATA40	GAIN40		
9	DATA9	GAIN9	DATA25	GAIN25	DATA41	GAIN41		
10	DATA10	GAIN10	DATA26	GAIN26	DATA42	GAIN42		
11	DATA11	GAIN11	DATA27	GAIN27	DATA43	GAIN43		
12	DATA12	GAIN12	DATA28	GAIN28	DATA44	GAIN44		
13	DATA13	GAIN13	DATA29	GAIN29	DATA45	GAIN45		
14	DATA14	GAIN14	DATA30	GAIN30	DATA46	GAIN46		
15	DATA15	GAIN15	DATA31	GAIN31	DATA47	GAIN47		
16	DATA16	GAIN16	DATA32	GAIN32	DATA48	GAIN48		

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

TABLE 4-2. ANALOG INPUT CARD REGISTER ASSIGNMENTS, CONTINUED

	PAGE 9		PAGE 10		PAGE 11		PAGE 12	
	word 1	word 2	word 1	word 2	word 1	word 2	word 1	word 2
1	ZERO1	GAIN1	ZERO17	GAIN17	ZERO33	GAIN33		
2	ZERO2	GAIN2	ZERO18	GAIN18	ZERO34	GAIN34		
3	ZERO3	GAIN3	ZERO19	GAIN19	ZERO35	GAIN35		
4	ZERO4	GAIN4	ZERO20	GAIN20	ZERO36	GAIN36		
5	ZERO5	GAIN5	ZERO21	GAIN21	ZERO37	GAIN37		
6	ZERO6	GAIN6	ZERO22	GAIN22	ZERO38	GAIN38		
7	ZERO7	GAIN7	ZERO23	GAIN23	ZERO39	GAIN39		
8	ZERO8	GAIN8	ZERO24	GAIN24	ZERO40	GAIN40		
9	ZERO9	GAIN9	ZERO25	GAIN25	ZERO41	GAIN41		
10	ZERO10	GAIN10	ZERO26	GAIN26	ZERO42	GAIN42		
11	ZERO11	GAIN11	ZERO27	GAIN27	ZERO43	GAIN43		
12	ZERO12	GAIN12	ZERO28	GAIN28	ZERO44	GAIN44		
13	ZERO13	GAIN13	ZERO29	GAIN29	ZERO45	GAIN45		
14	ZERO14	GAIN14	ZERO30	GAIN30	ZERO46	GAIN46		
15	ZERO15	GAIN15	ZERO31	GAIN31	ZERO47	GAIN47		
16	ZERO16	GAIN16	ZERO32	GAIN32	ZERO48	GAIN48		

	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1	GAIN1	GAIN17	GAIN33	
2	GAIN2	GAIN18	GAIN34	
3	GAIN3	GAIN19	GAIN35	
4	GAIN4	GAIN20	GAIN36	
5	GAIN5	GAIN21	GAIN37	
6	GAIN6	GAIN22	GAIN38	
7	GAIN7	GAIN23	GAIN39	
8	GAIN8	GAIN24	GAIN40	
9	GAIN9	GAIN25	GAIN41	CARD CONFIG
10	GAIN10	GAIN26	GAIN42	0
11	GAIN11	GAIN27	GAIN43	CARD STATUS
12	GAIN12	GAIN28	GAIN44	0
13	GAIN13	GAIN29	GAIN45	CARD ID REG
14	GAIN14	GAIN30	GAIN46	0
15	GAIN15	GAIN31	GAIN47	0
16	GAIN16	GAIN32	GAIN48	BIF

4.7 PIN ASSIGNMENTS AND CABLING

Table 4-3 shows the signals that are routed to the card connector pins on the edge of the card. The connector numbering scheme is shown in figure 3-11, at the end of Section III of this manual.

Table 4-3. HP 25501A I/O Connector Module Pin Assignments

CONNECTOR	PINS	CONNECTION	CONNECTOR	PINS	CONNECTION
A1J1	1,2	ID Resistor	A2J1	1,2	ID Resistor
A1J1	3	Ground	A2J1	3	Ground
A1J2	1,2,3	Channel 1	A2J2	1,2,3	Channel 9
A1J3	1,2,3	Channel 2	A2J3	1,2,3	Channel 10
A1J4	1,2,3	Channel 3	A2J4	1,2,3	Channel 11
A1J5	1,2,3	Channel 4	A2J5	1,2,3	Channel 12
A1J6	1,2,3	Channel 5	A2J6	1,2,3	Channel 13
A1J7	1,2,3	Channel 6	A2J7	1,2,3	Channel 14
A1J8	1,2,3	Channel 7	A2J8	1,2,3	Channel 15
A1J9	1,2,3	Channel 8	A2J9	1,2,3	Channel 16
Note that Pins 1, 2, and 3 of J2 through J9 in each connector have the following connections: Pin 1 (+ Input), Pin 2 (- Input), and Pin 3 (Ground).					

The connection between the ADC card and the field wiring is made with one of two cables:

HP 25551A (analog card cable with screw terminations)

HP 25551B (analog card cable, unterminated)

4.8 CALIBRATION PROCEDURE

If the ADC card is not operating according to its specifications, calibration may be required. After calibration, the overall operation of the ADC card can be verified by performing the verification tests described in the HP 2250 Diagnostics and Verification Manual, part no. 25595-90001. Specific instructions for calibrating the ADC card are contained in the following paragraphs.

4.8.1 EQUIPMENT REQUIRED

The following is a list of equipment required for calibration:

EQUIPMENT	USE
HP 3455A Digital Voltmeter	Reference voltages, zero, and gain adjustments.
HP 3310A Function Generator	Common Mode Rejection adjustment.
HP 180A Oscilloscope, with HP 1806A Low-Frequency Differential Plug-In	Common Mode Rejection adjustment, and Sample to Hold pedestal adjustment.
Accurate DC voltage source. Electronic Development Corp. Model 501J, or equivalent	PGA Gain adjustment, and ADC calibration
Extender Card	Provides access to the HP 25501A

4.8.2 PRELIMINARY PROCEDURES

a. Turn the HP 2250 system power OFF.

CAUTION

The ADC card contains static-sensitive components. Be sure to use appropriate anti-static procedures when you handle the card. (The pages on "Safety Considerations" at the beginning of this manual describe the anti-static procedures that you should follow.) Failure to follow these procedures may result in damage to the card.

b. Using the appropriate anti-static procedures, remove the HP HP 25501 card from its slot and insert the extender card in its place. Then insert the HP 25501A card into the extender card.

c. Turn on power to the HP 2250 system and ensure that it passes self-test.

d. At the controller you are using (HP 1000, HP 9826, etc.), call the HP 2250 exerciser program (MCX, for example) and issue the command:

ID(1,n)!

where "n" is the number of function card slots in your HP 2250 system. The ID codes of the function cards installed in the HP 2250 system should be returned, and the ID code of 1 should be returned from the slot that the HP 25501A is in.

e. From the exerciser program, issue the following command:

AI(adc slot,1)!

f. Two items should be returned:

1. A condition code of 0, indicating that the command executed correctly.

2. The data from the conversion on channel 1, which should should be any integer between -32768 and + 32767. Because no data was put into the card, you can't expect to know what the the data should be. All that is being determined with the command is whether the card will perform a conversion.

g. If step f. was successful (an integer between -32768 and +32767 was returned), the calibration can be started.

4.8.3 COMMON MODE REJECTION ADJUSTMENT

Perform the following steps:

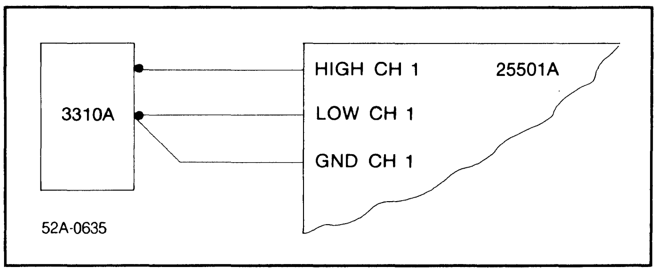
a. From the exerciser program, issue the command:

AI(adc slot,1)!

b. Set the output of the 3310A function generator to the following:

Frequency:	100 Hz
Function:	Sine wave
Amplitude:	10 volts peak (20 volts peak-to-peak)
DC offset:	Zero

c. Connect the function generator to the input of the HP 25501A as shown below:



d. Connect the + input of the HP 1806A CH A plug to the D/SE TEST POINT on the HP 25501A.

e. Connect the - input of the HP 1806A CH B plug to the PGA GND TEST POINT on the HP 25501A.

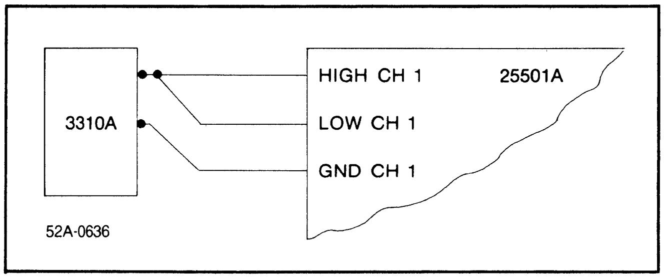
f. Connect the ground clips of both probes to the PGA GND TEST POINT on the HP 25501A.

g. Set the scope vertical sensitivity to 5V/div, the time base to 5msec/div, the trigger mode to internal, AC, and + slope. (Experiment to get a clear picture.)

h. Verify that there is a 20 volt peak-to-peak sine wave coming out of the D/SE amplifier (the test point that the + probe is connected to.

i. If there is a 20 v p-p sine wave at this point, then you are ready to perform the Common Mode Rejection adjustment. If the 20 v p-p sine wave is not present, the HP 25501A card is defective.

j. Connect the output of the 3310A to the input of the HP 255501A as shown below:



k. Increase the sensitivity of the scope to approximately 5mV/div. You should see a sine wave with an amplitude of from 1 mV p-p to 10 mV p-p.

l. Adjust R103 on the HP 25501A for a minimum output as viewed on the scope. (Anything below 1 mV p-p is acceptable, as this corresponds to > 80 db of common mode rejection.) Use the BANDWIDTH LIMIT switch on the scope, if necessary to eliminate noise on the display.

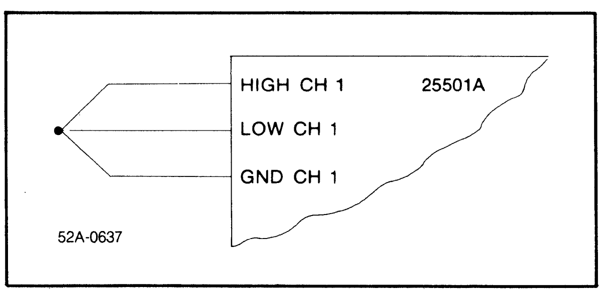
m. If the output cannot be adjusted for < 1 mV p-p, the HP 25501A card is defective.

4.8.4 SAMPLE-TO-HOLD DYNAMIC OFFSET ADJUSTMENT

Perform the following:

a. Disconnect the 3310A function generator from the HP 25501A.

b. Short the high and low inputs on the HP 25501A to its ground as shown below:



c. From the exerciser program, issue the following command:

REP(0);REW(B0);BLOCK READ(adc slot,1,10000);NEXT!

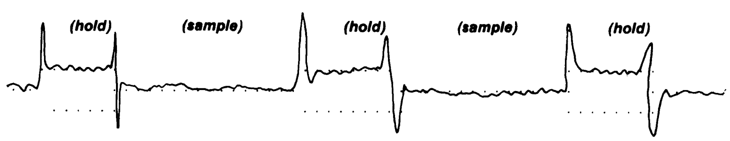
This command sets up a high speed AI loop; no data will be returned. The HP 25501A is taking readings with a short pause after every 10000 readings.

d. Move the + probe of the scope from the D/SE TEST POINT (from the previous test) to the S/H TEST POINT. Leave the - probe on the PGA GND TEST POINT.

e. Set the scope vertical sensitivity to 20 mV/div, AC coupled, and the time base to 5 usec/div.

f. A square, or similar, wave should appear on the scope. Adjust R66 (JUMP) on the HP 25501A so that the amplitude of the square wave decreases. Increase the scope sensitivity as necessary until it is in the 5 mV/div scale. MAKE SURE THAT THE BANDWIDTH LIMIT SWITCH IS IN THE 500 kHz POSITION FOR THIS TEST!

g. You should observe a waveform similar to that shown below:



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h. Continue to adjust R66 until the line between sample and hold is as straight as possible (< 1 mV).

i. The test is now complete. Remove the + and - scope probes and ground clips from their respective test points.

j. Issue the HPIB CLEAR message (CLEAR n on an HP 9826 desktop computer, where "n" is the interface number of the HP-IB interface, or CL from the MCX exerciser program on the HP 1000).

4.8.5 AUTORANGING REFERENCE VOLTAGE ADJUSTMENT

Perform the following:

a. Connect the digital voltmeter - lead to the PGA GND test point and the + lead to the + 10V TEST POINT on the HP 25501A.

b. Ensure that the digital voltmeter is in DC volts, autorange.

c. Adjust R92 (+10 REF) on the HP 25501A until the voltmeter reads +10.070 volts, plus or minus 2 mV.

d. Move the voltmeter + lead to the -10V TEST POINT.

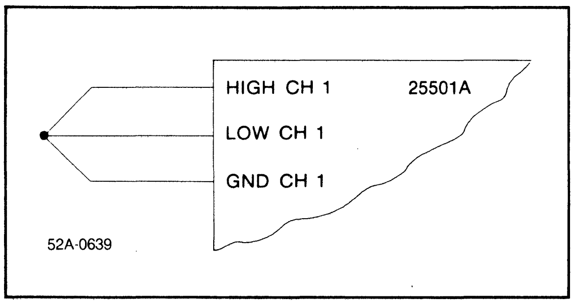
e. Adjust R98 (-10 REF) on the HP 25501A until the voltmeter reads -10.070 volts, plus or minus 2 mV.

4.8.6 PGA AND SUMMING AMPLIFIER OFFSET ADJUST

Perform the following:

a. Remove any test equipment still connected from the previous test.

b. Connect the input of the HP 25501A Channel 1 as shown below:



c. From the exerciser program, issue the following command:

GAIN(adc slot,1)122 DREAD(adc slot,1)!

Three data items should be returned:

1. A zero condition condition code.

2. Any value, which should be ignored.

3. 122, which is the gain code for a PGA gain of 8.

d. Connect the + lead of the digital voltmeter to the PGA TEST POINT, and the - lead to the PGA GND TEST POINT on the HP 25501A.

e. The digital voltmeter should read between +/- 100 mV.

f. Adjust R82 (PGA ZERO) on the HP 25501A until the voltmeter reads zero, plus or minus 0.4 mV.

g. From the exerciser program, issue the following command:

GAIN(adc slot,1)98 DREAD(adc slot,1)!

The first returned data item should be 0, ignore the second data item returned, and the third data item should be 98, which is the PGA gain code for unity gain.

h. Connect the + lead of the voltmeter to the ADC TEST POINT, and the - lead to the AGND TEST POINT on the HP 25501A.

i. Set SW1 (CALIB) as follows:

1 -- CLOSED

2 -- CLOSED

3 -- CLOSED

4 -- OPEN

j. The digital voltmeter should read between plus and minus 30 mV.

k. Adjust R37 (INO) on the HP 25501A until the voltmeter reads plus or minus 0.2 mV.

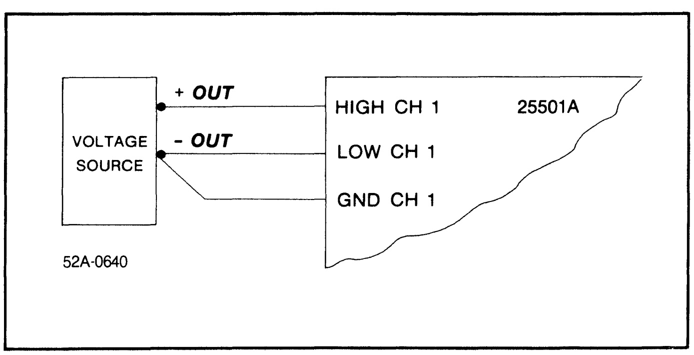
l. Set SW1 to OPEN, CLOSED, CLOSED, OPEN.

4.8.7 PGA GAIN ADJUST

Perform the following:

a. Remove any test equipment still connected from the previous test.

b. Connect the voltage source to the input of the HP 25501A as shown below:



c. Connect the + lead of the voltmeter to the PGA TEST POINT and the - lead to the PGA GND TEST POINT.

d. From the exerciser program, issue the following command:

```
GAIN(adc slot,1)98 AI(adc slot,1)!
```

e. Switch the voltage source between plus and minus 10 volts and verify that the digital voltmeter reads plus or minus 10 volts, respectively, with a tolerance of +/- 2 mV.

f. Set the voltage source to +5 volts, and then issue the following command:

```
GAIN(adc slot,1)106 AI(adc slot,1)!
```

This sets the PGA gain to 2.

g. Adjust R95 (G=2) on the HP 25501A until the voltmeter reads +10 volts, +/- 0.5 mV.

h. Set the voltage source to +2.5 volts, and issue the following command:

```
GAIN(adc slot,1)114 AI(adc slot,1)!
```

This sets the PGA gain to 4.

i. Adjust R90 (G=4) on the HP 25501A until the voltmeter reads +10 volts, +/- 0.5 mV.

j. Set the voltage source to +1.25 volts, and issue the following command:

```
GAIN(adc slot,1)122 AI(adc slot,1)!
```

This sets the PGA gain to 8.

k. Adjust R84 (G=8) on the HP 25501A until the voltmeter reads +10 volts, +/- 0.5 mV.

l. Issue the command RES! to complete this test.

4.8.8 ADC GAIN ADJUST

Perform the following:

a. Remove any test equipment still connected from the previous test.

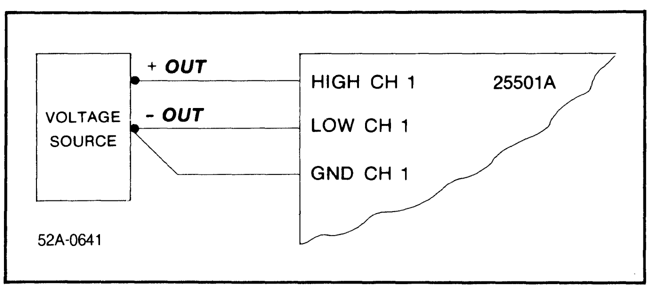
b. Issue the following command:

```
CPA(0,0,20);WPA;BLOCK AID(adc slot,1,50)!
```

This sets the HP 25501A to pace at 20 usec, and requests 50 analog double word readings. These readings should be processed as shown in the following example program:

```
    LUTERM=LOGLU(SLU)                                 !Get terminal LU
    READ(LU2250) CC                                   !Read condition code
    IF(CC .NE. 0)CALL ERROR                           !Go to error handler
                                                       if problem
    READ(LU2250) (V(I),I=1,100)                       !Gather the 100 data
                                                       items
    SUM = 0
    DO 10 I = 1,99,2                                  !DO loop to sum the
                                                       50 readings
    SUM=SUM + (V(I)*0.025) + (V(I+1)*0.000001)
10  CONTINUE
    AVERGE = SUM/50                                   !Calculate average of
                                                       50 readings
    WRITE(LUTERM,20) AVERGE
20  FORMAT("Average = "F9.5,"volts")                  !Display average
    GOTO XXXX                                         !Repeat
```

c. Connect the voltage source to the input of the HP 25501A as shown below:



d. Set the value of the voltage source to 0 volts DC.

e. Set SW1 (CALIB) to CLOSED, CLOSED, CLOSED, OPEN.

f. Start the program running. You should observe a reading of approximately -0.06 volts.

g. Be sure power has been applied to the card for at least 5 minutes before proceeding.

h. On the HP 25501A, adjust the potentiometer marked ZERO until the display reads 0.00000, +/- 0.000500 volts. (An occasional noise jump outside the range may occur, this is normal.)

i. Set the voltage source to +5 volts.

j. On the HP 25501A, adjust the potentiometer marked +5VOLT until the display reads +5.00000, +/- 0.000500.

k. Set SW1 on the HP 25501A to OPEN, CLOSED, CLOSED, OPEN.

l. Set the voltage source to + 10 volts.

m. On the HP 25501A, adjust the potentiometer marked +10VOLT until the display reads +10.00000, +/- 0.000500.

n. Set the voltage source to -10 volts.

o. On the HP 255501A, adjust the potentiometer marked -10VOLT until the display reads -10.00000, +/- 0.000500.

p. Set the voltage source to +10, +5, 0, -5, and -10 and determine that the display corresponds with the above voltages plus or minus 1.25 mV. If not, recalibrate the card from step d.

Section V
HP 25502A 32-Channel High-Level Multiplexer

5.1 INTRODUCTION

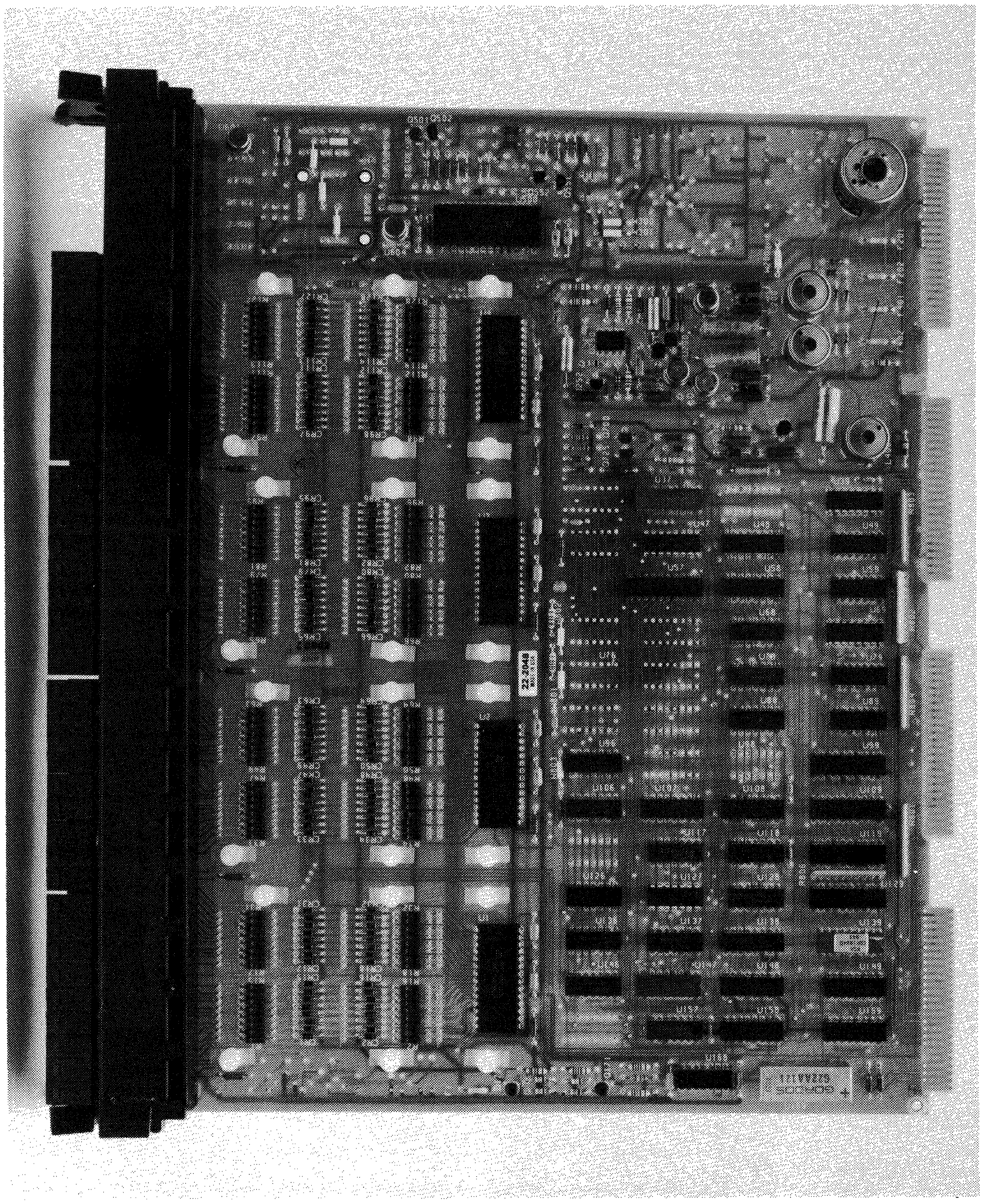
This section provides information for the HP 25502A 32-Channel High-Level Multiplexer (HLMUX) card. Included are specifications and a functional description. Installation information for the card is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

5.2 DESCRIPTION

The HP 25502A, shown in figure 5-1, adds high-level, low common-mode voltage input expansion capability to the HP 25501A 16-Channel High-Speed Analog Input card. The HLMUX has 32 differential input channels with provision for low-pass RC (resistance-capacitance) filtering for noise reduction or bandwidth control on each channel. High-level inputs can be accepted at a channel-to-channel scan rate of 50 kHz.

5.3 SPECIFICATIONS

Specifications for the HLMUX card are provided in table 5-1.



2250-83H

Figure 5-1. HP 25502A 32-Channel High-Level Multiplexer

Table 5-1. HP 25502A Specifications

FEATURES

32 differential input channels

Auto zero

Input filtering

Current loop sense resistors

Input protection

Open sensor detection

APPLICATIONS

Used for direct interface to high level, low common mode inputs without external amplifiers.

PROGRAMMING INFORMATION

AI command:	Return voltage from specified channel in millivolts
AIR command:	Return voltage in HP 1000 real format
AID command:	Return voltage in double integer format
AIC command:	Return data from channel in raw card format
GAIN command:	Set gain (range) on a specified channel
RGAIN command:	Read gain (range) on a specified channel
CLB command:	Perform an auto-zero cycle
RANGE command:	Set analog range

Table 5-1. HP 25502A Specifications (Continued)

ELECTRICAL CHARACTERISTICS

INPUT RANGES AND RESOLUTIONS:

Input Channel Span	Input Channel Range	Resolution	DM*	CM**	PGA GAIN
20 V	+/- 10 V	1.25 mV	+/- 10	+/- 10	1
10 V	+/- 5 V	625 uV	+/- 5	+/- 10	2
5 V	+/- 2.5 V	312.5 uV	+/- 2.5	+/- 10	4
2.5 V	+/- 1.25 V	156.25 uV	+/- 1.25	+/- 10	8

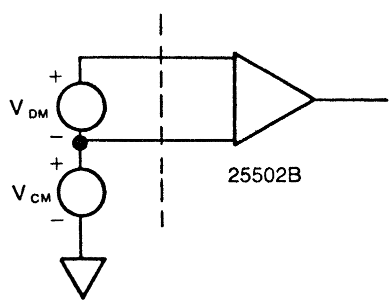
* DM = differential input voltage

** CM = common mode input voltage

In all cases: ¦CM¦+¦DM¦ < 10 V

MAXIMUM INPUT VOLTAGE FOR RATED ACCURACY

Maximum differential and maximum common mode must be less than or equal to +/- 10 volts.



Example: With a common mode voltage of +4 volts, the maximim differential voltage that can be measured would be +/- 6 volts.

Table 5-1. HP 25502A Specifications (Continued)

SOURCE IMPEDANCE AND IMBALANCE

Maximum source impedance for rated accuracy: 1 K ohm

Maximum source imbalance for rated accuracy: 1 K ohm

Maximum return impedance for rated accuracy: 10 K ohm

INPUT IMPEDANCE

Power On: >= 10 M ohm shunted by <= 80 pf

Power Off: 1 K ohm +/- 10% to ground

2 K ohm +/- 20% to any other signal input line

INPUT OVERLOAD PROTECTION

No damage will occur below the following levels:

Power On Steady State: Up to +/- 25 volts on any ONE input signal line to ground, or to any other ONE signal input line.

Derate by 1.0 volts for each additional overloaded signal input line.

Example: What is the maximum simultaneous overload on 4 input channels?

There are two input lines per channel, therefore,

Maximum overload voltage per line = 25 - (4 x 2 x 1)
= 17 volts

Transient: +/- 50 volts on any ONE input signal line to ground or to any other ONE input signal line, for a maximum of 10 seconds.

Table 5-1. HP 25502A Specifications (Continued)

Power Off Steady State:	Up to +/- 15 volts on any ONE input signal line to ground or to any other ONE input signal line. Up to +/- 12 volts on all input signal lines simultaneously.

COMMON MODE REJECTION AND CROSSTALK

Common Mode Rejection:

Source Imbalance	Frequency	Common Mode Rejection (db)	uV of Error Referred to Input Per 1 Volt of Common Mode
0 ohm	DC to 30 kHz	82	79
	DC to 10 kHz	72	251
	DC to 25 kHz	62	794
1 K ohm	DC to 100 Hz	76	158
	DC to 500 Hz	63	707
	DC to 5 Hz	42	7.94 uV

AC Crosstalk:

Frequency	Crosstalk Rejection (db)	uV of Error Referred to Input Per 1 Volt of Signal on Adjacent Channel
DC to 25 kHz	92	25
5 kHz	88	39
10 kHz	83	70
25 kHz	76	150

Overload Crosstalk:

Readings on channels adjacent to overload channel will meet AC crosstalk specification for overload voltages within the input overload specification.

Table 5-1. HP 25502A Specifications (Continued)

Overload Recovery Time:

Readings within rated accuracy within 1 msec after removal of maximum overload, or after changing channels from overloaded to non-overloaded channel.

ACCURACY

Static Accuracy (DC frequency inputs) without autocalibrate cycle at 25 degrees C:

Accuracy % of Full Scale	Volts Referred to Input
0.01% +/- 1/2 LSB	+/- 1 mV +/- 1/2 LSB

AC Accuracy:

Full Range: 1 LSB degradation point 860 Hz, 3 db degradation point 86 kHz

Small Signal: 1 LSB degradation point 10 kHz, 3 db degradation point > 500 kHz

NOISE

Effective RMS Volts Referred to Input: 1 mV

Effective RMS Volts Peak-to-Peak Referred to Input: 25 mV

TEMPERATURE COEFFICIENTS (0 TO 70 DEGREES C)

Drift % Full Scale Referred to Input/Degrees C: 0.0007%/degree C

Drift uV Referred to Input/Degrees C: 70 uV/degree C

Gain Drift % Full Scale Referred to Input/Degrees C: 0.004%/degree C

Table 5-1. HP 25502A Specifications (Continued)

PHYSICAL CHARACTERISTICS	
Width:	28.91 cm (11.38 in.)
Depth:	34.8 cm (13.54 in.)
Height:	3.5 cm (1.38 in.)
Weight:	680 grams (1.5 lbs)

5.4 INPUT SIGNAL CONDITIONING

Low-pass filtering and/or current-loop termination for the HLMUX is provided by up to four Signal Conditioning Modules (SCMs). The four SCMs, and their descriptions, are listed below:

SCM NUMBER	CHANNELS	DESCRIPTION
HP 25540A	8	Blank (user supplies components)
HP 25540B	8	Passive filter network capacitors
HP 25540C	8	Passive filter network current-loop resistors
HP 25540D	8	Passive filter network current-loop resistors and filter capacitors

The specifications, component diagram, and schematic for the SCMs are provided in Section III, table 3-5.

The SCMs, if they are to be used, must be installed on the HLMUX card before the card is plugged into the measurement and control unit. SCMs may be installed in any or all of four locations (A5, A6, A7, and A8) on the card, depending on which input channels are to receive signal conditioning.

Install the SCM, with its component side up, by aligning its six guide holes to the six guide pins on the HLMUX card and pressing the SCM firmly into place. The physical orientation of the guide pins prevents improper installation of the SCM. The guide pins also serve as spacers to keep the SCM elevated from the surface of the card. Refer to the HP 2250 Installation and Start-Up Manual, part number 02250-90012, for further information on installing an SCM.

The installation of an SCM connects the J1, J2, and J3 sockets on the SCM to the J1, J2, and J3 pins, respectively, on the HLMUX card.

If a blank SCM (HP 25540A) has been ordered, you must install signal conditioning components on the SCM before it is connected to the HLMUX card. Resistors with a value of 250 ohms +/- 0.02 percent should be used for current-loop termination. The capacitor values to be used will vary depending on the desired cut-off frequency needed for the low-pass filter.

The following formula may be used to select the desired capacitor values. The value computed will set the low-pass filter to the 3-db point with a 6-db-per-octave rolloff at the desired frequency.

C = 1/(2*pi*R*F)

where

C is the value of the capacitor to be determined, in farads
R is 2400 ohms
F is the desired frequency, in hertz

5.5 FUNCTIONAL DESCRIPTION

Figure 5-2 contains a functional block diagram showing the input/output buses and the major functions of the HLMUX.

The HLMUX, upon command from the processor unit (HP 2104), selects an analog input voltage, buffers it, and transfers it to the HP 25501A 16-Channel High-Speed Analog Input (ADC) card. The ADC card converts the value of the analog voltage to an equivalent 14-bit digital word and transfers it along with the system gain to the HP 25071A Measurement and Control Interface (MCI) card.

Up to 32 input channels can be connected directly to the input connectors of the HLMUX. Each input channel has a DATA register associated with it. An analog input channel is selected by addressing its associated DATA register.

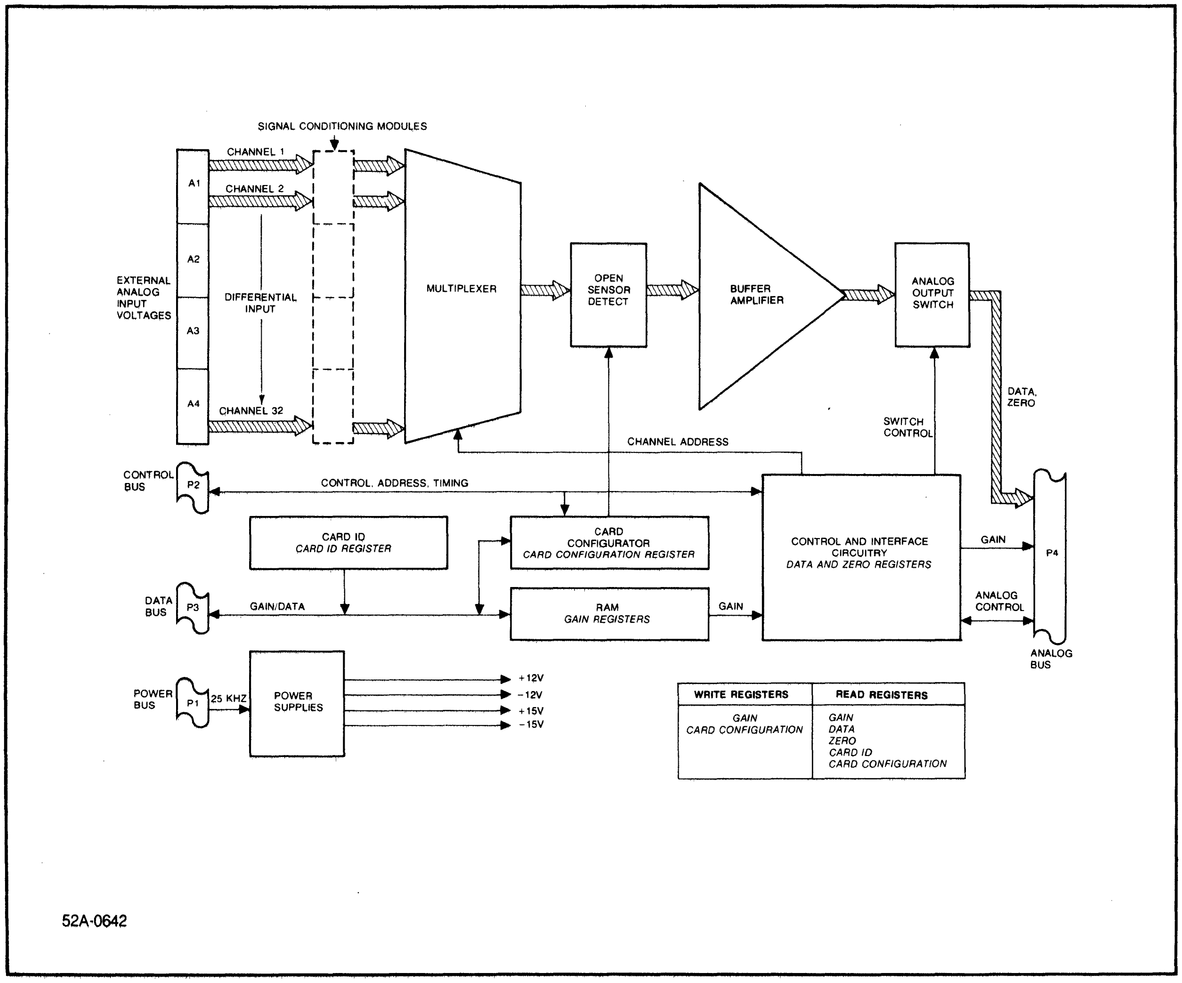


Figure 5-2. HP 25502A Functional Block Diagram

The selected analog input voltage passes through a Multiplexer and Open Sensor Detect circuit to the input of a Buffer Amplifier.

The Open Sensor Detect circuit is used to locate an open circuit or line in one of the input channels. When an open (the input lines are actually broken or separated from the input) is detected during a read, the Programmable Gain Amplifier (PGA) circuit on the HLMUX is driven positively to full scale. This full-scale voltage is then sent to the HP 25501A analog input card for processing.

An overrange condition will produce the same results as an open circuit. That is, if an overrange input voltage is applied, a full-scale reading will occur. To determine if an overrange condition or an open is causing the full-scale reading, lower the voltage to a known value within the selected range, and check if the full-scale reading still exists. An alternate method would be to program the gain to unity if the overrange is occurring on a higher range, and then observe the results. If the high reading still exists, there probably is an open in the input circuit.

Another condition that can approach or reach a full-scale reading is that caused by a high resistance in the input circuit.

Each differential input channel also has an associated GAIN register. These GAIN registers can be programmed to one of the following gains: 1, 2, 4, 8, or autorange. The gains are not used by the HLMUX, but are sent from the HLMUX to the ADC card to control its Programmable Gain Amplifier (PGA) when a read DATA is requested.

After buffering by the Buffer Amplifier, the analog voltage passes through the closed Analog Output Switch and then to the ADC card.

5.6 REGISTER ASSIGNMENTS

Register assignments for the HLMUX card are shown in table 5-2.

The analog input cards (ADC and multiplexers) all have the same register assignments. The raw data returned from the card is in double word format. The register assignments allow for future expansion up to 48 channels per card.

To read the zero-reference voltage on a channel, read from the appropriate register on pages 9-11. Programming the gain for a channel is done by writing to the registers on pages 13-15.

A read of the card status register always will return 0.

TABLE 5-2. ANALOG INPUT REGISTER ASSIGNMENTS

	PAGE 1		PAGE 2		PAGE 3		PAGE 4	
	word 1	word 2	word 1	word 2	word 1	word 2	word 1	word 2
	1st	2nd	1st	2nd	1st	2nd		
1	DATA1	GAIN1	DATA17	GAIN17	DATA33	GAIN33		
2	DATA2	GAIN2	DATA18	GAIN18	DATA34	GAIN34		
3	DATA3	GAIN3	DATA19	GAIN19	DATA35	GAIN35		
4	DATA4	GAIN4	DATA20	GAIN20	DATA36	GAIN36		
5	DATA5	GAIN5	DATA21	GAIN21	DATA37	GAIN37		
6	DATA6	GAIN6	DATA22	GAIN22	DATA38	GAIN38		
7	DATA7	GAIN7	DATA23	GAIN23	DATA39	GAIN39		
8	DATA8	GAIN8	DATA24	GAIN24	DATA40	GAIN40		
9	DATA9	GAIN9	DATA25	GAIN25	DATA41	GAIN41		
10	DATA10	GAIN10	DATA26	GAIN26	DATA42	GAIN42		
11	DATA11	GAIN11	DATA27	GAIN27	DATA43	GAIN43		
12	DATA12	GAIN12	DATA28	GAIN28	DATA44	GAIN44		
13	DATA13	GAIN13	DATA29	GAIN29	DATA45	GAIN45		
14	DATA14	GAIN14	DATA30	GAIN30	DATA46	GAIN46		
15	DATA15	GAIN15	DATA31	GAIN31	DATA47	GAIN47		
16	DATA16	GAIN16	DATA32	GAIN32	DATA48	GAIN48		

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

TABLE 5-2. ANALOG INPUT CARD REGISTER ASSIGNMENTS, CONTINUED

	PAGE 9 word 1	PAGE 9 word 2	PAGE 10 word 1	PAGE 10 word 2	PAGE 11 word 1	PAGE 11 word 2	PAGE 12 word 1	PAGE 12 word 2
1	ZERO1	GAIN1	ZERO17	GAIN17	ZERO33	GAIN33		
2	ZERO2	GAIN2	ZERO18	GAIN18	ZERO34	GAIN34		
3	ZERO3	GAIN3	ZERO19	GAIN19	ZERO35	GAIN35		
4	ZERO4	GAIN4	ZERO20	GAIN20	ZERO36	GAIN36		
5	ZERO5	GAIN5	ZERO21	GAIN21	ZERO37	GAIN37		
6	ZERO6	GAIN6	ZERO22	GAIN22	ZERO38	GAIN38		
7	ZERO7	GAIN7	ZERO23	GAIN23	ZERO39	GAIN39		
8	ZERO8	GAIN8	ZERO24	GAIN24	ZERO40	GAIN40		
9	ZERO9	GAIN9	ZERO25	GAIN25	ZERO41	GAIN41		
10	ZERO10	GAIN10	ZERO26	GAIN26	ZERO42	GAIN42		
11	ZERO11	GAIN11	ZERO27	GAIN27	ZERO43	GAIN43		
12	ZERO12	GAIN12	ZERO28	GAIN28	ZERO44	GAIN44		
13	ZERO13	GAIN13	ZERO29	GAIN29	ZERO45	GAIN45		
14	ZERO14	GAIN14	ZERO30	GAIN30	ZERO46	GAIN46		
15	ZERO15	GAIN15	ZERO31	GAIN31	ZERO47	GAIN47		
16	ZERO16	GAIN16	ZERO32	GAIN32	ZERO48	GAIN48		

	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1	GAIN1	GAIN17	GAIN33	
2	GAIN2	GAIN18	GAIN34	
3	GAIN3	GAIN19	GAIN35	
4	GAIN4	GAIN20	GAIN36	
5	GAIN5	GAIN21	GAIN37	
6	GAIN6	GAIN22	GAIN38	
7	GAIN7	GAIN23	GAIN39	
8	GAIN8	GAIN24	GAIN40	
9	GAIN9	GAIN25	GAIN41	CARD CONFIG
10	GAIN10	GAIN26	GAIN42	0
11	GAIN11	GAIN27	GAIN43	CARD STATUS
12	GAIN12	GAIN28	GAIN44	0
13	GAIN13	GAIN29	GAIN45	CARD ID REG
14	GAIN14	GAIN30	GAIN46	0
15	GAIN15	GAIN31	GAIN47	0
16	GAIN16	GAIN32	GAIN48	BIF

5.7 PIN ASSIGNMENTS AND CABLING

Table 5-3 shows the signals that are routed to the card connector pins on the edge of the card. The connector numbering scheme is shown in figure 3-11, at the end of Section III of this manual.

Table 5-3. HP 25502A I/O Connector Module Pin Assignments

CONNECTOR	PINS	CONNECTION	CONNECTOR	PINS	CONNECTION
A1J1	1,2	ID Resistor	A3J1	1,2	ID Resistor
A1J1	3	Ground	A3J1	3	Ground
A1J1	4	Not used	A3J1	4	Not used
A1J2	1,2,3	Channel 1	A3J2	1,2,3	Channel 17
A1J3	1,2,3	Channel 2	A3J3	1,2,3	Channel 18
A1J4	1,2,3	Channel 3	A3J4	1,2,3	Channel 19
A1J5	1,2,3	Channel 4	A3J5	1,2,3	Channel 20
A1J6	1,2,3	Channel 5	A3J6	1,2,3	Channel 21
A1J7	1,2,3	Channel 6	A3J7	1,2,3	Channel 22
A1J8	1,2,3	Channel 7	A3J8	1,2,3	Channel 23
A1J9	1,2,3	Channel 8	A3J9	1,2,3	Channel 24
A2J1	1,2	ID Resistor	A4J1	1,2	ID Resistor
A2J1	3	Ground	A4J1	3	Ground
A2J1	4	Not used	A4J1	4	Not used
A2J2	1,2,3	Channel 9	A4J2	1,2,3	Channel 25
A2J3	1,2,3	Channel 10	A4J3	1,2,3	Channel 26
A2J4	1,2,3	Channel 11	A4J4	1,2,3	Channel 27
A2J5	1,2,3	Channel 12	A4J5	1,2,3	Channel 28
A2J6	1,2,3	Channel 13	A4J6	1,2,3	Channel 29
A2J7	1,2,3	Channel 14	A4J7	1,2,3	Channel 30
A2J8	1,2,3	Channel 15	A4J8	1,2,3	Channel 31
A2J9	1,2,3	Channel 16	A4J9	1,2,3	Channel 32

Note that Pins 1, 2, and 3, of J2 through J9 in each connector have the following connections: Pin 1 (+ input), Pin 2 (- Input), and Pin 3 (Ground).

The connection between the HLMUX card and the field wiring is made with one of two cables:

HP 25551A (analog card cable with screw terminations)

HP 25551B (analog card cable, unterminated)

5.8 CALIBRATION

If the HLMUX card is not operating according to specifications, you may need to calibrate it. After calibration, you can verify the overall operation of the card by performing the tests described in the HP 2250 Measurement and Control Processor Diagnostic and Verification Manual, part number 25595-90001.

The following paragraphs contain specific instructions for calibrating the HLMUX card.

5.8.1 EQUIPMENT REQUIRED

The HLMUX calibration procedure requires the following equipment:

1) HP 3455A digital voltmeter

2) A shorting connector (part number 25590-60010), as pictured in figure 5-3.

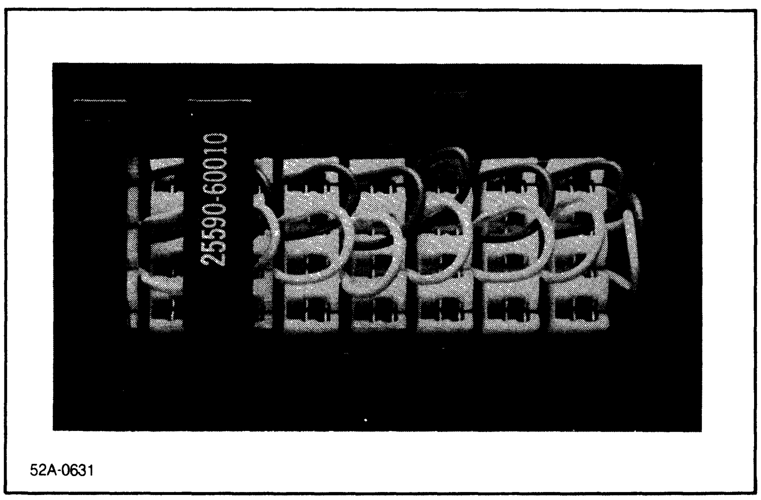


Figure 5-3. Shorting connector

5.8.2 PRELIMINARY PROCEDURE

1) Remove the field wiring assemblies (FWAs) from the HP 25502A HLMUX card.

2) Turn the HP 2250 system power OFF, then turn it back ON. Make sure that the system passes the self-test.

3) Allow the HLMUX card to reach normal operating temperature. This warm-up period usually takes 15 minutes; if, however, the card was already at operating temperature before you turned the power off, you can go ahead with the calibration as long as the power was not off for more than 30 seconds.

4) From the controller you are using (HP 1000, HP 9826, HP-85, etc.) issue the command

   ```
   ID(1,n)!
   ```

   to the HP 2250, where n is the number of function card slots in your HP 2250 system. (If you are using the MCX exerciser program, just type in "CARDS".) This will cause the ID codes of the function cards in your system to be returned, and an ID code of 2 should be returned for the slot that contains the HP 25502A HLMUX card.

5) Issue the following command from the controller to the HP 2250:

   ```
   AI(slot,1)
   ```

   where "slot" is the slot number of the HLMUX card. This will cause the HP 2250 to make an analog reading of channel 1 of the HLMUX card. Two values should be returned:

   a) A condition code of 0, indicating that the command executed correctly.

   b) The datum from the conversion on channel 1; this should be any integer in the range of -32768 to 32767. (Since channel 1 is not connected to a known voltage, there is no way of knowing what the "correct" reading should be. All that you are doing here is verifying that the card is able to take a reading.)

6) If step 5 was successful (that is, if an integer between -32768 and 32767 was returned), you are ready to proceed with the calibration.

5.8.3 OFFSET VOLTAGE ADJUSTMENT

There is only one adjustment to be made in calibrating the HP 25502A HLMUX card; this is the adjustment of the operational amplifier offset voltage. Do the following:

1) Short the inputs of the first channel of the HLMUX card. This involves connecting the HIGH , LOW, and GROUND pins for the channel. This is most easily done with the shorting connector (part number 25590-60010) shown in figure 5-3. Connect the shorting connector to the first block of eight channels on the card, just as though you were connecting a field wiring cable. (You don't have to use the shorting connector if you don't want to; it's just an awful lot easier than trying to fit alligator clips into that tiny area.)

CAUTION

> If you try to short the inputs with alligator clips, be sure that you don't touch the fourth row of pins. Some of these pins carry power for the thermocouple reference connectors, and an accidental connection between these power pins and the other pins could damage the card. We recommend that you use the shorting connector.

2) Issue the following command to the HP 2250:

   AI(slot,1)

   where "slot" is the number of the slot that contains the HLMUX card.

3) Set the voltmeter to the lowest voltage range and connect it between test points HIGH and LOW on the front edge of the HLMUX card.

4) Adjust potentiometer R601 until you get a reading of zero on the voltmeter.

5) That's all there is to it. Reconnect the FWAs and you're ready to go.

Section VI
HP 25503A 32-Channel Low-Level Multiplexer

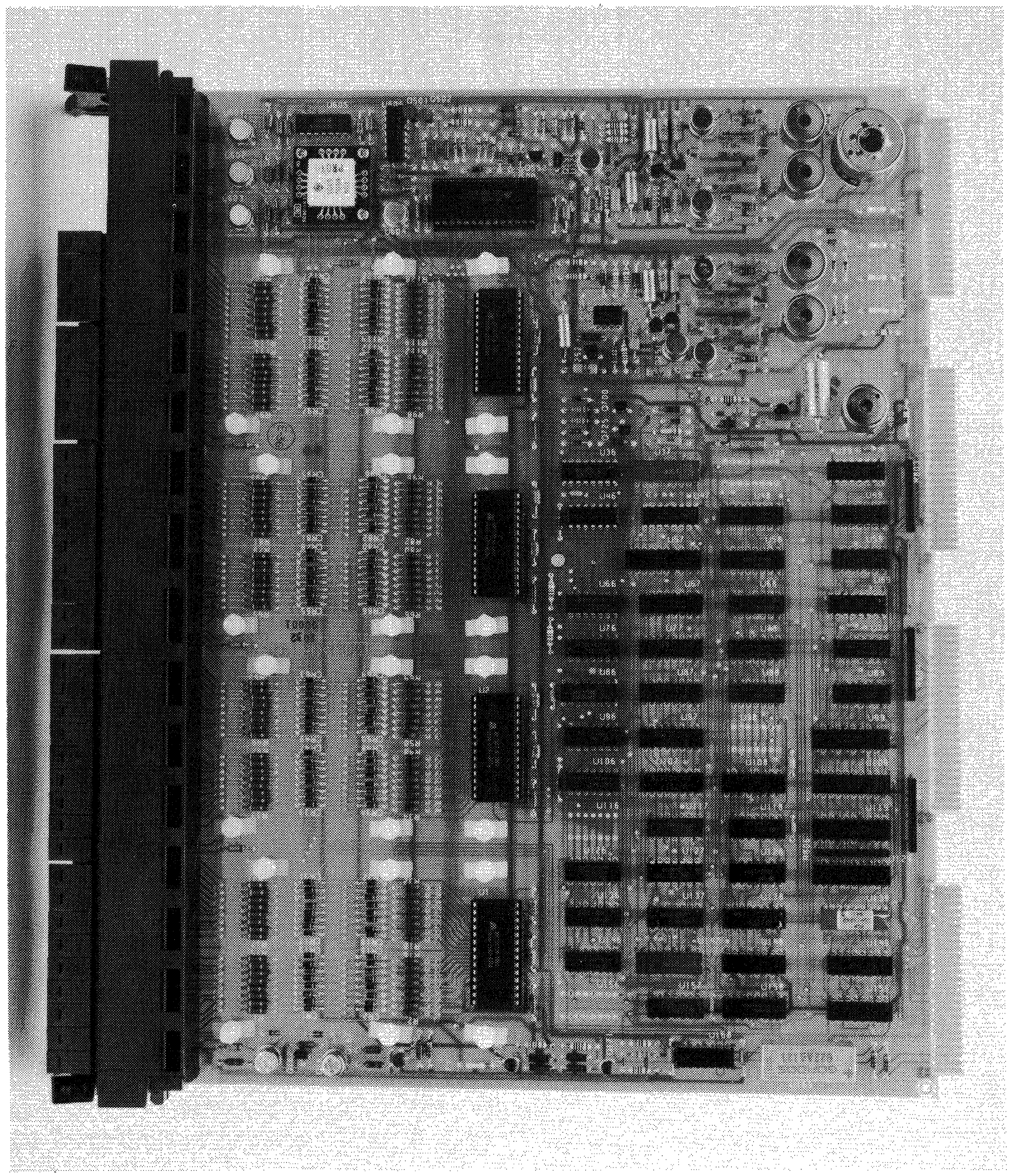
6.1 INTRODUCTION

This section provides information for the HP 25503A 32-Channel Low-Level Multiplexer (LLMUX) card. Included are specifications and a functional description. Installation information for the card is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

6.2 DESCRIPTION

The LLMUX, shown in figure 6-1, adds low-level, low common-mode voltage input expansion capability to the HP 25501A 16-Channel High-Speed Analog Input (ADC) card. The LLMUX has 32 differential input channels with provision for low-pass RC (resistance-capacitance) filtering for noise reduction or bandwidth control on each channel. Low-level inputs, down to 1.56 microvolts, can be accepted at a channel-to-channel scan rate of 20 kHz.

The LLMUX offers programmable gains of 1, 10, and 100 and is primarily used in interfacing to microvolt and millivolt inputs, such as the input from thermocouple devices. If external thermocouple measurements are to be made, a sensor power supply located on the LLMUX is used to provide power to an optionally available HP 25594A Thermocouple Reference Connector (TRC). The TRC provides a reference voltage and inputs from up to 15 various thermocouple devices and is described in Section XIV of this manual.



2250-85H

Figure 6-1. HP 25503A 32-Channel Low-Level Multiplexer

6.3 SPECIFICATIONS

Table 6-1 contains specifications for the LLMUX.

6.4 INPUT SIGNAL CONDITIONING

Low-pass filtering and/or current-loop termination for the LLMUX is provided by up to four Signal Conditioning Modules (SCMs). The four SCMs, and their descriptions, are listed below:

SCM NUMBER	CHANNELS	DESCRIPTION
HP 25540A	8	Blank (user supplies components)
HP 25540B	8	Passive filter network capacitors
HP 25540C	8	Passive filter network current-loop resistors
HP 25540D	8	Passive filter network current-loop resistors and filter capacitors

The specifications, component diagram, and schematic for the SCMs are provided in Section III, table 3-5.

The SCMs, if they are to be used, must be installed on the LLMUX card before the card is installed in the measurement and control unit.

SCMs may be installed in any or all of four locations (A5, A6, A7, and A8), depending on which input channels are to receive signal conditioning.

Install the SCM, with its component side up, by aligning its six guide holes to the six guide pins on the LLMUX card and pressing the SCM firmly into place. The physical orientation of the guide pins prevents improper installation of the SCM. The guide pins also serve as spacers to keep the SCM elevated from the surface of the card. Refer to the HP 2250 Installation and Start-Up Manual, part number 02250-90012, for further information on installing an SCM.

The installation of an SCM connects the J1, J2, and J3 sockets on the SCM to the J1, J2, and J3 pins, respectively, on the LLMUX card.

Table 6-1. HP 25503A Specifications

FEATURES

32 differential input channels

Programmable gain amplifier

Auto zero

Input filtering

Current loop sense resistors

Input protection

Open sensor detection

APPLICATIONS

Used for direct interface to low level, low common mode analog inputs without external amplifiers.

PROGRAMMING INFORMATION

AI command:	Return voltage from specified channel in millivolts
AIR command:	Return voltage in HP 1000 real format
AID command:	Return voltage in double integer format
AIC command:	Return data from channel in raw card format
GAIN command:	Set gain (range) on a specified channel
RGAIN command:	Read gain (range) on a specified channel
CLB command:	Perform an auto-zero cycle
RANGE command:	Set analog range

Table 6-1. HP 25503A Specifications (Continued)

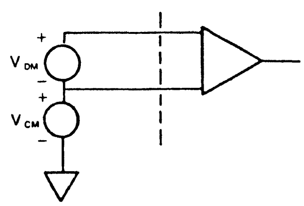
ELECTRICAL CHARACTERISTICS

INPUT RANGES AND RESOLUTION WHEN USED WITH HP 25501A

Input Channel Span (Full-Scale)	Range (Full-Scale)	Resolution (1 LSB)	Total PGA Gain
20 V	+/- 10 V	1.25 mV	1
10 V	+/- 5 V	625 uV	2
5 V	+/- 2.5 V	312 uV	4
2.5 V	+/- 1.25 V	156 uV	8
2 V	+/- 1 V	125 uV	10
1 V	+/- 500 mV	62.5 uV	20
500 mV	+/- 250 mV	31.2 uV	40
250 mV	+/- 125 mV	15.6 uV	80
200 mV	+/- 100 mV	12.5 uV	100
100 mV	+/- 50 mV	6.25 uV	200
50 mV	+/- 25 mV	3.12 uV	400
25 mV	+/- 12.5 mV	1.56 uV	800

MAXIMUM INPUT VOLTAGE FOR RATED ACCURACY

Maximum differential voltage and maximum common mode voltage must be less than or equal to +/- 10 volts



Example: On the +/- 250 mV range, the maximum differential input allowed is 250 mV, therefore,

$$V_{CM} (max) = 10 - 250 mV = 9.750 V$$

INPUT IMPEDANCE:

Power On: >= 10 M ohm shunted by <= 80 pF
Power Off: 1 K ohm +/- 10% to ground, 2 K ohm +/- 20% to any other input signal line

Table 6-1. HP 25503A Specifications (Continued)

SOURCE IMPEDANCE AND IMBALANCE

Maximum source impedance for rated accuracy: 1 K ohm

Maximum source imbalance for rated accuracy: 1 K ohm

Maximum return impedance for rated accuracy: 10 K ohm

INPUT OVERLOAD PROTECTION

No damage will occur below the following levels:

Power On Steady State: Up to +/- 25 volts on any ONE input signal line to ground, or to any other ONE input signal input line. Derate by 1.0 volts for each additional overloaded input signal line.

Example: What is the maximum simultaneous overload on 4 input channels?

There are two input lines per channel, therefore,

Maximum overload voltage per line = 25 - (4 x 2 x 1)
= 17 volts

Power On Transient: +/- 50 volts on any ONE input signal line to ground, or to any other ONE input signal line, for a maximum of 10 seconds.

Power Off Steady State: Up to +/- 15 volts on any ONE input signal line to ground, or to any other ONE input signal line. Up to +/- 12.5 volts on all input signl lines simultaneously.

Table 6-1. HP 25503A Specifications (Continued)

COMMON MODE REJECTION AND CROSSTALK

Common Mode Rejection:

Source Imbalance	Frequency	Common Mode Rejection (db)	uV of Error Referred to Input per 1 Volt of Common Mode
0 ohm	DC to 3 kHz	82	79
	DC to 10 kHz	72	251
	DC to 25 kHz	62	794
1 K ohm	DC to 100 Hz	76	158
	DC to 500 Hz	63	707
	DC to 5 kHz	42	7.94

AC Crosstalk:

Frequency	Crosstalk Rejection (db)	uV of Error Referred to Input Per 1 Volt of Common Mode
DC to 2.5 kHz	92	25
5 kHz	88	39
10 kHz	83	70
25 kHz	76	158

Overload Crosstalk:

Readings on channels adjacent to overloaded channel will meet AC crosstalk specification for overload voltages within the input overload specification.

Overload Recovery Time:

Readings within rated accuracy within 1 msec after removal of maximum overload or after changing channels from overloaded to non-overloaded channel.

Table 6-1. HP 25503A Specifications (Continued)

ACCURACY

Static Accuracy (DC frequency inputs) without autocalibrate cycle at 25 degrees C:

Range	Accuracy % of Full Scale (+/- 1/2 LSB)	Volts Referred to Input (+/- 1/2 LSB)
+/- 10 V	0.01%	+/- 1 mV
+/- 1 V	0.08%	+/- 200 uV
+/- 0.1 V	0.04%	+/- 40 uV

AC Accuracy

Bandwidth Full Range:

Input Range	1 LSB Degradation Point	3 db Degradation Point
+/- 10 V	860 Hz	86 kHz
+/- 1 V	430 Hz	43 kHz
+/- 0.1 V	320 Hz	32 kHz

Small Signal:

Input Range	1 LSB Degradation Point	3 db Degradation Point
+/- 10 V	10 kHz	> 500 kHz
+/- 1 V	560 Hz	56 kHz
+/- 0.1 V	320 Hz	35 kHz

NOISE:

Input Channel Range	Effective mV RMS Referred to Input	uV Peak-to-Peak Referred to Input
+/- 10 V	1 mV	2.5 mV
+/- 1 V	50 uV	250 uV
+/- 0.1 V	10 uV	70 uV

Table 6-1. HP 25503A Specifications (Continued)

TEMPERATURE COEFFICIENTS (0 to 70 degrees C):

Range	Drift % Full Scale Referred to Input Degrees C	Gain Drift % Full Scale Referred to Input Degrees C
+/- 10 V	0.007%/degree C	0.004%/degree C
+/- 1 V	0.002%/degree C	0.004%/degree C
+/- 0.1 V	0.02%/degree C	0.004%/degree C

PHYSICAL CHARACTERISTICS:

Width: 28.91 cm (11.38 inches)

Depth: 34.8 cm (13.54 inches)

Height: 3.5 cm (1.38 in.)

Weight: 680 grams (1.5 lbs)

If a blank SCM (HP 25540A) has been ordered, you must install signal conditioning components on the SCM before it is connected to the LLMUX card. Resistors with a value of 250 ohms +/- 0.02 percent should be used for current-loop termination. The capacitor values to be used will vary depending on the desired cut-off frequency needed for the low-pass filter. The following formula may be used to select the desired capacitor values. The value computed will set the low-pass filter to the 3-db point with a 6-db-per-octave rolloff at the desired frequency.

C = 1/(2*pi*R*F)

where

C is the value of the capacitor to be determined, in farads
R is 2400 ohms
F is the desired frequency, in hertz

6.5 FUNCTIONAL DESCRIPTION

Figure 6-2 is a functional block diagram showing the input/output buses and the major functions of the LLMUX.

The LLMUX, upon command from the processor unit (HP 2104), selects an analog input voltage, amplifies it, and transfers it to the ADC card. The ADC card converts the value of the analog voltage to an equivalent 14-bit digital word and transfers it along with the system gain value to the HP 12071A Measurement and Control Interface (MCI) card.

Up to 32 input channels can be connected directly to the input connectors of the LLMUX, with each channel capable of providing an independent analog input voltage. Each input channel has a DATA register associated with it in the Control and Interface Circuitry. An analog input channel is selected by addressing its associated DATA register.

The selected analog input voltage passes through a Mutiplexer and an Open Sensor Detect circuit to the input of a Programmable Gain Amplifier (PGA).

Each differential input channel has an associated GAIN register. At any time, you may program a GAIN register to change or read its contents. Each of these GAIN registers can be programmed to one of the following gains: 1, 10, or 100. Also, gains of 1, 2, 4, 8, or autorange are available in the GAIN registers and are used to control the gain of the ADC card PGA. When a reading is requested from a specific channel, the contents of the associated GAIN register automatically set the gain of the LLMUX and ADC card Programmable Gain Amplifiers to the programmed value.

After amplification in the LLMUX PGA, the analog voltage passes through the closed Analog Output Switch and then to the ADC card. The gain data (1, 2, 4, 8, or autorange) from the GAIN register is also at this time sent to the ADC card when a read DATA is requested to set the gain of the ADC card PGA.

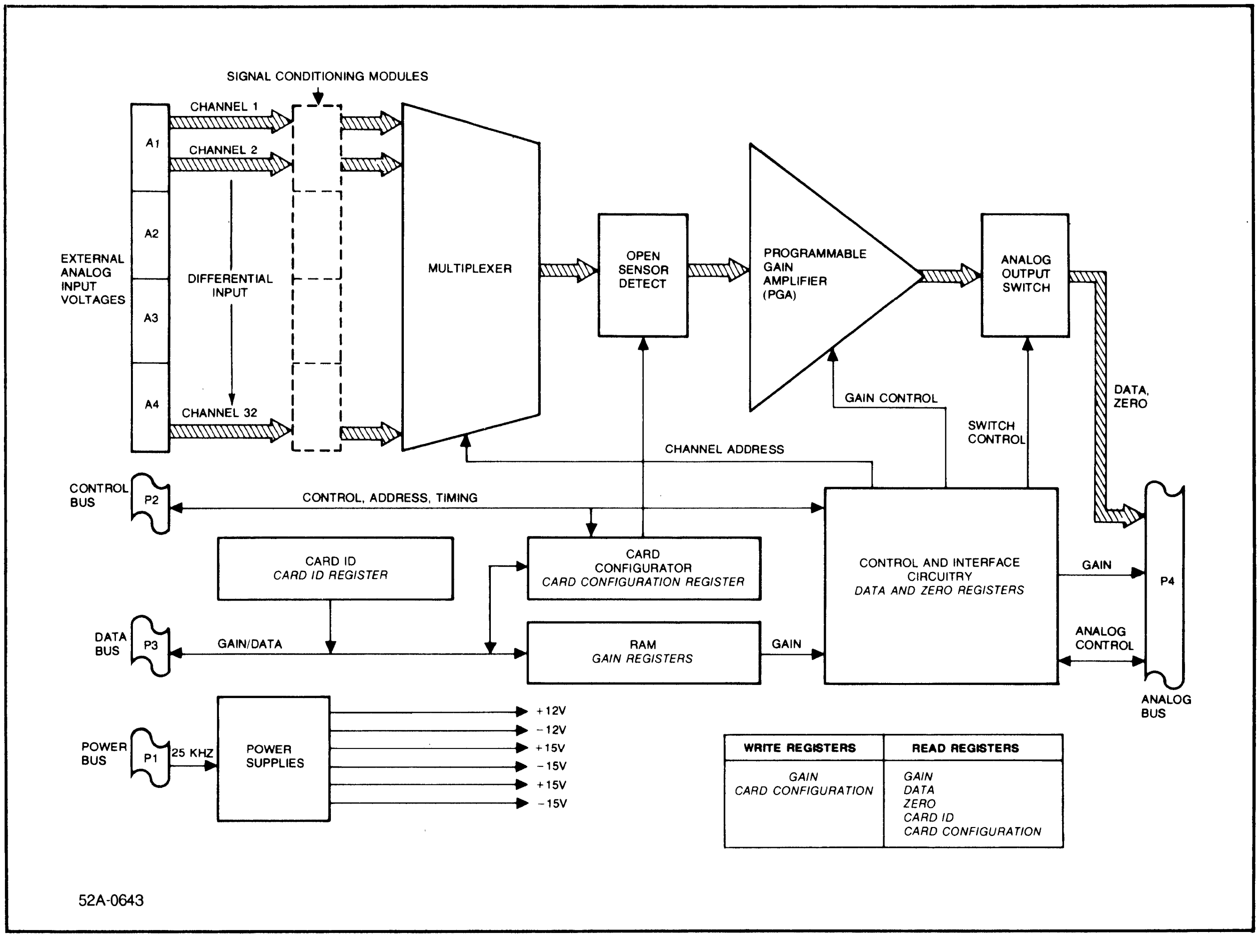


Figure 6-2. HP 25503A Functional Block Diagram

6.6 REGISTER ASSIGNMENTS

Register assignments for the LLMUX card are shown in table 6-2.

The analog input cards (ADC and multiplexers) all have the same register assignments. The raw data returned from the card is in double word format. The register assignments allow for future expansion up to 48 channels per card.

To read the zero-reference voltage on a channel, read from the appropriate register on pages 9-11. Programming the gain for a channel is done by writing to the registers on pages 13-15.

The meaning of the configuration word of the analog input cards varies from card to card. For the LLMUX card, the following meanings apply:

Bit	Meaning
7	1 - Open sensor detection on 0 - Open sensor detection off

A read of the card status register always will return 0.

TABLE 6-2. ANALOG INPUT REGISTER ASSIGNMENTS

	PAGE 1 word 1	PAGE 1 word 2	PAGE 2 word 1	PAGE 2 word 2	PAGE 3 word 1	PAGE 3 word 2	PAGE 4 word 1	PAGE 4 word 2
	1st	2nd	1st	2nd	1st	2nd		
1	DATA1	GAIN1	DATA17	GAIN17	DATA33	GAIN33		
2	DATA2	GAIN2	DATA18	GAIN18	DATA34	GAIN34		
3	DATA3	GAIN3	DATA19	GAIN19	DATA35	GAIN35		
4	DATA4	GAIN4	DATA20	GAIN20	DATA36	GAIN36		
5	DATA5	GAIN5	DATA21	GAIN21	DATA37	GAIN37		
6	DATA6	GAIN6	DATA22	GAIN22	DATA38	GAIN38		
7	DATA7	GAIN7	DATA23	GAIN23	DATA39	GAIN39		
8	DATA8	GAIN8	DATA24	GAIN24	DATA40	GAIN40		
9	DATA9	GAIN9	DATA25	GAIN25	DATA41	GAIN41		
10	DATA10	GAIN10	DATA26	GAIN26	DATA42	GAIN42		
11	DATA11	GAIN11	DATA27	GAIN27	DATA43	GAIN43		
12	DATA12	GAIN12	DATA28	GAIN28	DATA44	GAIN44		
13	DATA13	GAIN13	DATA29	GAIN29	DATA45	GAIN45		
14	DATA14	GAIN14	DATA30	GAIN30	DATA46	GAIN46		
15	DATA15	GAIN15	DATA31	GAIN31	DATA47	GAIN47		
16	DATA16	GAIN16	DATA32	GAIN32	DATA48	GAIN48		

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

TABLE 6-2. ANALOG INPUT CARD REGISTER ASSIGNMENTS, CONTINUED

	PAGE 9 word 1	PAGE 9 word 2	PAGE 10 word 1	PAGE 10 word 2	PAGE 11 word 1	PAGE 11 word 2	PAGE 12 word 1	PAGE 12 word 2
1	ZERO1	GAIN1	ZERO17	GAIN17	ZERO33	GAIN33		
2	ZERO2	GAIN2	ZERO18	GAIN18	ZERO34	GAIN34		
3	ZERO3	GAIN3	ZERO19	GAIN19	ZERO35	GAIN35		
4	ZERO4	GAIN4	ZERO20	GAIN20	ZERO36	GAIN36		
5	ZERO5	GAIN5	ZERO21	GAIN21	ZERO37	GAIN37		
6	ZERO6	GAIN6	ZERO22	GAIN22	ZERO38	GAIN38		
7	ZERO7	GAIN7	ZERO23	GAIN23	ZERO39	GAIN39		
8	ZERO8	GAIN8	ZERO24	GAIN24	ZERO40	GAIN40		
9	ZERO9	GAIN9	ZERO25	GAIN25	ZERO41	GAIN41		
10	ZERO10	GAIN10	ZERO26	GAIN26	ZERO42	GAIN42		
11	ZERO11	GAIN11	ZERO27	GAIN27	ZERO43	GAIN43		
12	ZERO12	GAIN12	ZERO28	GAIN28	ZERO44	GAIN44		
13	ZERO13	GAIN13	ZERO29	GAIN29	ZERO45	GAIN45		
14	ZERO14	GAIN14	ZERO30	GAIN30	ZERO46	GAIN46		
15	ZERO15	GAIN15	ZERO31	GAIN31	ZERO47	GAIN47		
16	ZERO16	GAIN16	ZERO32	GAIN32	ZERO48	GAIN48		

	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1	GAIN1	GAIN17	GAIN33	
2	GAIN2	GAIN18	GAIN34	
3	GAIN3	GAIN19	GAIN35	
4	GAIN4	GAIN20	GAIN36	
5	GAIN5	GAIN21	GAIN37	
6	GAIN6	GAIN22	GAIN38	
7	GAIN7	GAIN23	GAIN39	
8	GAIN8	GAIN24	GAIN40	
9	GAIN9	GAIN25	GAIN41	CARD CONFIG
10	GAIN10	GAIN26	GAIN42	0
11	GAIN11	GAIN27	GAIN43	CARD STATUS
12	GAIN12	GAIN28	GAIN44	0
13	GAIN13	GAIN29	GAIN45	CARD ID REG
14	GAIN14	GAIN30	GAIN46	0
15	GAIN15	GAIN31	GAIN47	0
16	GAIN16	GAIN32	GAIN48	BIF

6.7 PIN ASSIGNMENTS AND CABLING

Table 6-3 shows the signals that are routed to the card connector pins on the edge of the card. The connector numbering scheme is shown in figure 3-11, at the end of Section III of this manual.

Table 6-3. HP 25503A I/O Connector Module Pin Assignments

CONNECTOR	PINS	CONNECTION		CONNECTOR	PINS	CONNECTION
A1J1	1,2	ID Resistor		A3J1	1,2	ID Resistor
A1J1	2	Ground		A3J1	2	Ground
A1J1	3	Thermocouple Supply (+)		A3J1	3	Thermocouple Supply (+)
A1J1	4	Thermocouple Supply (-)		A3J1	4	Thermocouple Supply (-)
A1J2	1,2,3	Channel 1		A3J2	1,2,3	Channel 17
A1J3	1,2,3	Channel 2		A3J3	1,2,3	Channel 18
A1J4	1,2,3	Channel 3		A3J4	1,2,3	Channel 19
A1J5	1,2,3	Channel 4		A3J5	1,2,3	Channel 20
A1J6	1,2,3	Channel 5		A3J6	1,2,3	Channel 21
A1J7	1,2,3	Channel 6		A3J7	1,2,3	Channel 22
A1J8	1,2,3	Channel 7		A3J8	1,2,3	Channel 23
A1J9	1,2,3	Channel 8		A3J9	1,2,3	Channel 24
A2J1	1,2	ID Resistor		A4J1	1,2	ID Resistor
A2J1	2	Ground		A4J1	2	Ground
A2J1	3	Thermocouple Supply (+)		A4J1	3	Thermocouple Supply (+)
A2J1	4	Thermocouple Supply (-)		A4J1	4	Thermocouple Supply (-)
A2J2	1,2,3	Channel 9		A4J2	1,2,3	Channel 25
A2J3	1,2,3	Channel 10		A4J3	1,2,3	Channel 26
A2J4	1,2,3	Channel 11		A4J4	1,2,3	Channel 27
A2J5	1,2,3	Channel 12		A4J5	1,2,3	Channel 28
A2J6	1,2,3	Channel 13		A4J6	1,2,3	Channel 29
A2J7	1,2,3	Channel 14		A4J7	1,2,3	Channel 30
A2J8	1,2,3	Channel 15		A4J8	1,2,3	Channel 31
A2J9	1,2,3	Channel 16		A4J9	1,2,3	Channel 32

Note that pins 1, 2, and 3 of J2 through J9 in each connector have the following connections: Pin 1 (+ input), Pin 2 (- Input), and Pin 3 (Ground).

The connection between the LLMUX card and the field wiring is made with one of three cables:

HP 25551A (analog card cable with screw terminations)

HP 25551B (analog card cable, unterminated)

HP 25594A (LLMUX card cable with thermocouple reference connector)

6.8 CALIBRATION

If the LLMUX card is not operating according to specifications, you may need to calibrate it. After calibration, you can verify the overall operation of the card by performing the tests described in the HP 2250 Measurement and Control Processor Diagnostic and Verification Manual, part number 25595-90001. The following paragraphs contain specific instructions for calibrating the LLMUX card.

6.8.1 EQUIPMENT REQUIRED

You will need the following equipment for calibrating the LLMUX card:

1) HP 3455A digital voltmeter.

2) Extender card, part number 25591-60001, as shown in figure 6-3.

3) Shorting connector, part number 25590-60010, as shown in figure 6-4.

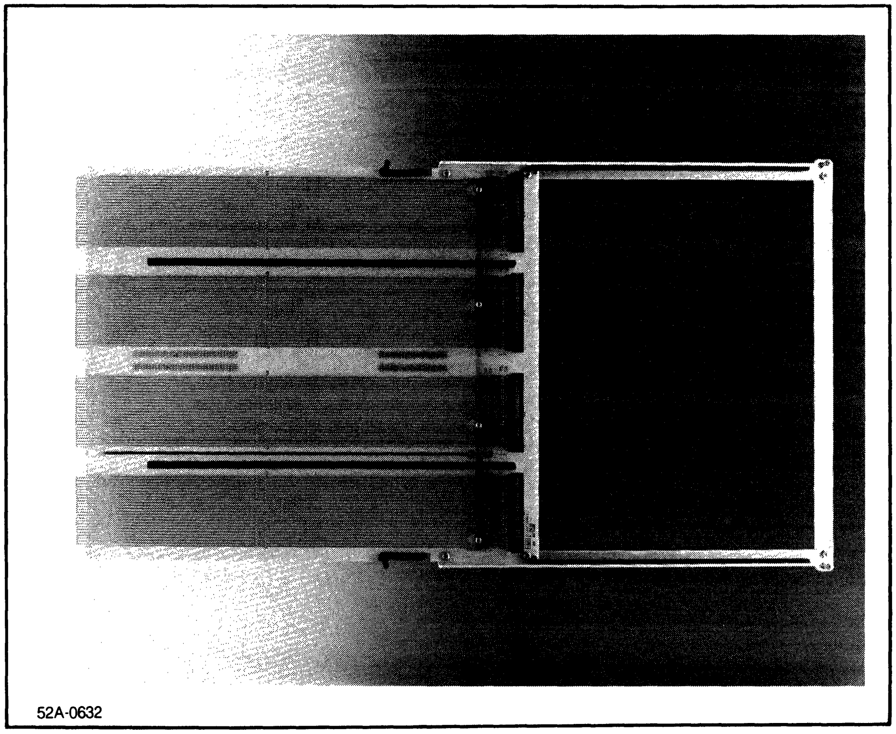


Figure 6-3. Extender card

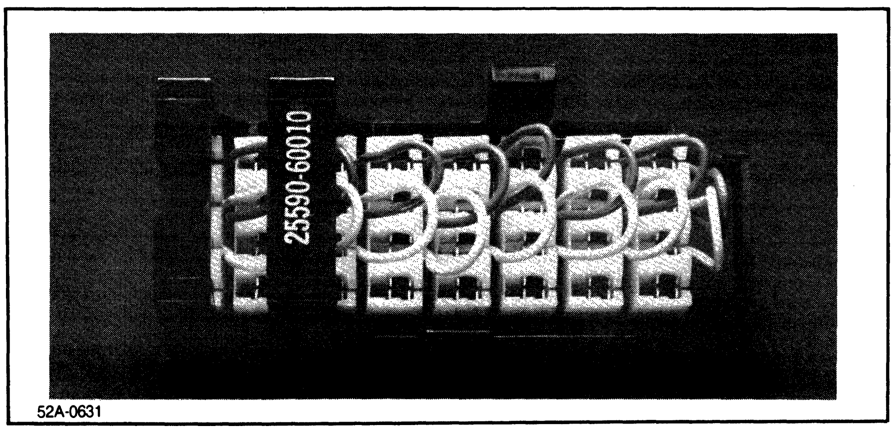


Figure 6-4. Shorting connector

6.8.2 PRELIMINARY PROCEDURE

1) Turn the power to the HP 2250 system OFF.

2) Remove the field wiring assemblies (FWAs) from the HP 25503A LLMUX card.

3) Remove the LLMUX card from its slot and insert the extender card in its place. Insert the LLMUX card into the extender card. Leave the FWAs disconnected.

CAUTION

The LLMUX card contains static-sensitive components. Be sure to use appropriate anti-static procedures when you handle the card. (The pages on "Safety Considerations" at the beginning of this manual describe the anti-static procedures that you should follow.) Failure to follow these procedures may result in damage to the card.

4) Turn power to the HP 2250 system ON and make sure that the system passes self-test.

5) Allow the LLMUX card to reach normal operating temperature. This warm-up period usually takes 15 minutes; if, however, the card was already at operating temperature before you turned the power off, and if the power was not off for more than 30 seconds, you can go ahead with the calibration procedure.

6) At the controller you are using (HP 1000, HP 9826, HP-85, etc.) issue the command

```
ID(1,n)!
```

to the HP 2250, where n is the number of function card slots in your HP 2250 system. (If you are using the MCX exerciser program, just type in "CARDS".) This will cause the ID codes of the function cards in your system to be returned, and an ID code of 3 should be returned for the slot that contains the HP 25503A LLMUX card.

7) Issue the following command from controller to the HP 2250:

```
AI(slot,1)
```

where "slot" is the slot number of the LLMUX card. This will cause the HP 2250 to make an analog reading of channel 1 of the LLMUX card. Two values should be returned:

a) A condition code of 0, indicating that the command executed correctly.

b) The datum from the conversion on channel 1; this should be any integer in the range of -32768 to 32767. (Since channel 1 is not connected to a known voltage, there is no way of knowing what the "correct" reading should be. All that you are doing here is verifying that the card is able to take a reading.)

8) If step 7 was successful (that is, if an integer between -32768 and 32767 was returned), you are ready to proceed with the calibration.

6.8.3 OFFSET VOLTAGE ADJUSTMENT

There are three adjustments to be made in calibrating the HP 25503A LLMUX card; they are all adjustments of operational amplifier offset voltages. Do the following:

1) Short the inputs of the first channel of the LLMUX card. This involves connecting the HIGH, LOW, and GROUND pins of the channel. This is most easily done with the shorting connector (part number 25590-60010) shown in figure 6-4. Connect the shorting connector to the first block of eight channels on the card, just as though you were connecting a field wiring cable. (You don't have to use the shorting connector if you don't want to, but we have found that using the connector is easier than trying to run wires between all those little pins.)

CAUTION

> If you do try to connect the pins with individual wires, be careful not to make contact with the fourth row of pins. These pins carry power for the thermocouple reference connectors, and an accidental connection between these pins and the other pins could damage the card. We recommend that you use the shorting connector.

2) Issue the following command to the HP 2250:

   AI(slot,1)

   where "slot" is the number of the slot that contains the LLMUX card.

3) Set the voltmeter to the lowest voltage range and connect it between points A and C (shown in figure 6-5) on the LLMUX card.

4) Adjust potentiometer R601 (on the front edge of the card) until you get a reading of zero on the voltmeter.

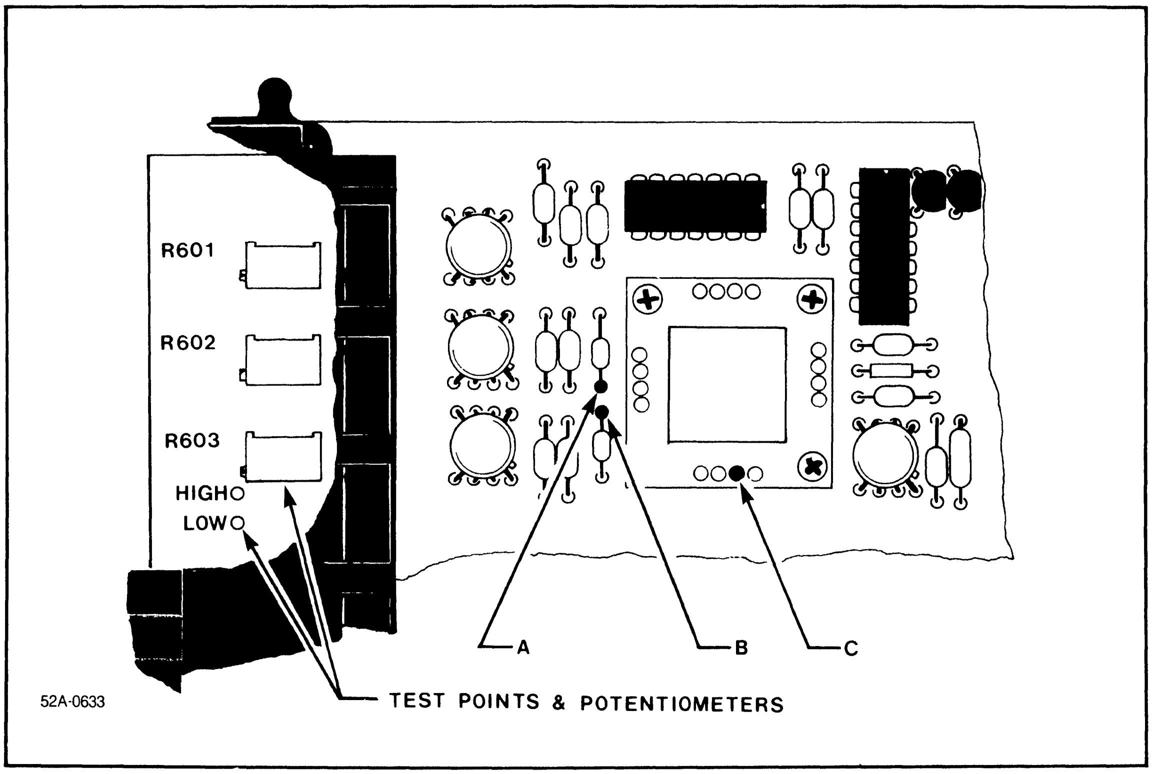


Figure 6-5. LLMUX Test Points and Adjustments

5) Connect the voltmeter between points B and C (shown in figure 6-5).

6) Adjust potentiometer R602 (on the front edge of the card) until you get a reading of zero on the voltmeter.

7) Connect the voltmeter between test points HIGH and LOW on the front edge of the card.

8) Adjust potentiometer R603 (on the front edge of the card) until you get a reading of zero on the voltmeter.

9) Calibration of the LLMUX card is now complete. To return to normal operation:

   a) Turn power to the HP 2250 system OFF.

   b) Remove the LLMUX card from the extender card.

CAUTION

> The LLMUX card contains static-sensitive components. Be sure to use appropriate anti-static procedures when you handle the card. (The pages on "Safety Considerations" at the beginning of this manual describe the anti-static procedures that you should follow.) Failure to follow these procedures may result in damage to the card.

   c) Remove the extender card from its slot and insert the LLMUX card in its place.

   d) Connect the FWAs to the LLMUX card.

   e) Turn power ON.

   The HP 2250 system is now ready to go.

Section VII
HP 25504 16-Channel Relay Multiplexer

7.1 INTRODUCTION

This section provides information for the HP 25504 16-Channel Relay Multiplexer (RLYMUX) card. Included are specifications and a functional description. Installation information for the card is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

7.2 DESCRIPTION

The RLYMUX adds low-level, high common-mode rejection (110 dB) input expansion capability to the HP 25501 16-Channel High-Speed Analog Input (ADC) card. It also offers true ground isolation, a channel-to-channel scan rate of 1 kHz, programmable open sensor detection, and programmable gains of 0.1, 1, 10, and 100.

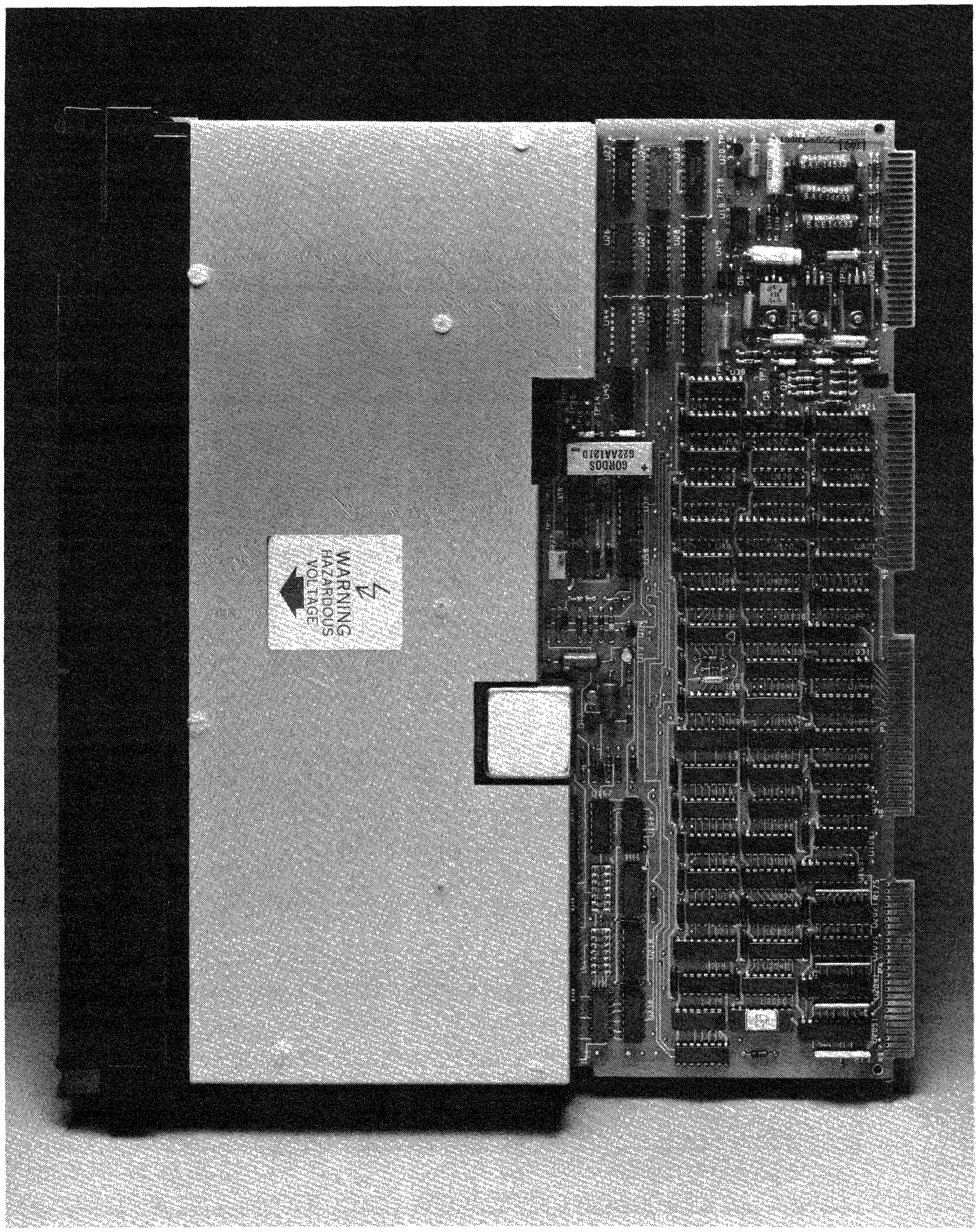
Figure 7-1 shows the RLYMUX card with its metal shield in place. Figure 7-3, later in this section, shows the card with the shield removed.

The RLYMUX has 16 input channels that provide relay switching for analog input voltages. The relay for each input channel is located on a replaceable relay module. Full information on the relay modules is contained in the paragraphs on "Relay Modules", later in this section.

Each relay switches three input lines per channel: HI, LOW, and GUARD. The HI and LOW lines provide standard input for analog input voltages. The GUARD is used when common-mode voltages and noise are a problem. The relay switch for the GUARD is designed to close before the HI and LOW relay switches, to prevent common-mode surge currents from flowing in the RLYMUX Programmable Gain Amplifier (PGA).

To minimize noise in the input signals, the GUARD line of the cable should be connected to the LOW side of the user-supplied voltage source (as far from the RLYMUX card as possible). The GUARD should run through the shield wire of any three-wire system. If it is determined that the GUARD is not required, the GUARD of the input line should be tied to its LOW input at the field wiring assembly (as close to the RLYMUX card as practicable). The LOW inputs of all channels can be tied to their respective GUARD inputs by setting the switch on the front of the RLYMUX card to the ON position.

Common-mode isolation on the RLYMUX is provided by magnetic coupling to break the ground loops between user-supplied voltage sources and the HP 2250 system.



52A-0627

Figure 7-1. HP 25504 16-Channel Relay Multiplexer

The RLYMUX can receive microvolt and millivolt inputs from devices such as thermocouples. If thermocouple measurements are to be made, a thermocouple power supply located on the RLYMUX is used to provide power to an optionally available HP 25594B Thermocouple Reference Connector. The Thermocouple Reference Connector provides connections for up to 15 various thermocouple devices and is described in Section XIII of this manual.

Appropriate Use. The RLYMUX is appropriate for high-common-mode applications that require continuous low-speed scanning or occasional high-speed scanning. Applications that require continuous high-speed scanning are not suitable for the RLYMUX, since they use up the finite lifetime of the relay modules inordinately fast; for such applications the HLMUX or LLMUX, with appropriate external signal conditioning, is better.

7.3 SPECIFICATIONS

Table 7-1 contains specifications for the RLYMUX.

Table 7-1. HP 25504 Specifications

FEATURES
16 channels, scanning at 500 Hz, single-channel input at 10 kHz
14-bit resolution
Programmable full scale ranges from +/- 100 V to +/- 12.4 mV
+/- 350 volt peak common mode range
Programmable open sensor detection
Current loop option
Relay life: 10 million to 100 million cycles (40 million avg.)
APPLICATIONS
Interfaces to devices such as transducers and thermocouples.

Table 7-1. HP 25504A Specifications (Continued)

PROGRAMMING INFORMATION

AI command:	Return voltage from specified channel in millivolts
AIR command:	Return voltage in HP 1000 real format
AID command:	Return voltage in double integer format
AIC command:	Return data from channel in raw card format
GAIN command:	Set gain (range) on a specified channel
RGAIN command:	Read gain (range) on a specified channel
CLB command:	Perform an auto-zero cycle
RANGE command:	Set analog range

ELECTRICAL CHARACTERISTICS

INPUT RANGE AND RESOLUTION

		0.1	1.0	10.0	100.0
HP 25501A GAIN	1	+/- 100 V 12.5 mV	+/- 10.0 V 1.25 mV	+/- 1.0 V 125 mV	+/- 0.1 V 12.5 uV
	2	+/- 50 V 6.25 mV	+/- 5V 625 uV	+/- 0.5 V 62.5 uV	+/- 0.05 V 6.25 uV
	4	+/- 25 V 3.13 mV	+/- 2.5 V 313 uV	+/- 0.25 V 31.3 uV	+/- 0.025 V 3.13 uV
	8	+/- 12.5 V 1.56 mV	+/- 1.25 V 156 uV	+/- 0.125 V 15.6 uV	+/- 0.0125 V 1.56 uV

SPAN = 2 x absolute value (range)

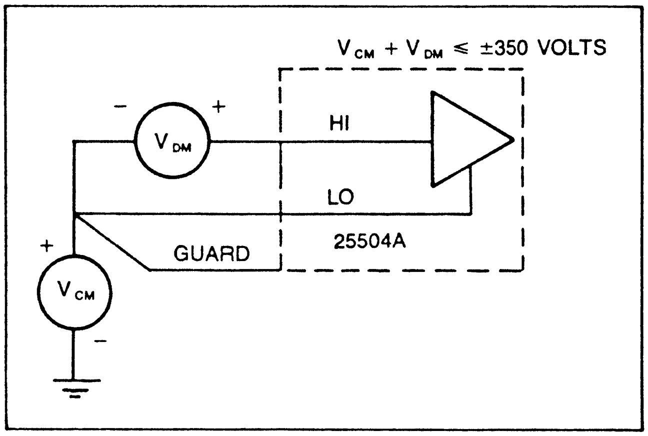
Table 7-1. HP 25504A Specifications (Continued)

COMMON MODE VOLTAGE LIMITS

Common Mode Voltage: 350 volts peak

Channel-to-Channel Common Mode Voltage: 350 volts peak

The potential difference between any two channels shall never exceed 350 volts peak. If channel 1 has a + 10 volt differential signal and a +100 volt common mode signal applied to its input, then channel 2 will have no more than 110 volts minus 350 volts (-240 volts) total (sum of differential and common mode) applied to its input.



COMMON MODE REJECTION AND CROSSTALK

Effective Common Mode Rejection*:

60 Hz	165 db	(average of ten HP 25501A readings)*
120 Hz	140 db	(average of ten HP 25501A readings)*

* Effective common mode rejection is defined as the sum of the common mode rejection of the HP 25504 and the normal mode rejection provided by the HP 25501 when used as a digital filter through the available MCL/50 commands. MCL/50, through the use of the CPACE and WPACE commands, allows the user to take a group of paced readings over a cycle of the common mode signal. These can then be averaged by applying the AAVERAGE command resulting in the Effective Common Mode Rejection outlined above.

Table 7-1. HP 25504A Specifications (Continued)

For a 60-Hz common mode signal, the pace rates would be set as follows:

Common Mode Period = 16.66 msec (1/60 Hz)

Pace Rate = 16.66/10 = 1.666 msec (10 readings)

For an individual HP 25504, the effective scan rate would be 60 Hz.

Common Mode Rejection (without signal averaging):

Source Imbalance	Frequency	Db
0 ohm	DC to 1 kHz	104
	DC to 5 kHz	90
	DC to 10 kHz	84
1 K ohm	DC to 50 Hz	110
	DC to 100 Hz	104
	DC to 500 Hz	90
	DC to 1 kHz	84

AC Crosstalk (Channel to Adjacent Channel):

Frequency	Db
DC to 50 Hz	-120
DC to 60 Hz	-118
DC to 100 Hz	-114

AC Crosstalk (1 Channel to 15 Off Channels)

Frequency	Db
50 Hz	-97
60 Hz	-95
100 Hz	-91

Table 7-1. HP 25504 Specifications (Continued)

SOURCE IMPEDANCE

Maximum Source Impedance for Rated Accuracy: 1 K ohm

Maximum Source Imbalance for Rated Accuracy: 1 K ohm

A 10 kHz low pass filter at each channel input (on the relay module) has the following characteristics:

Source impedance of sensor	Frequency at which signal is rolled off by 3 dB
0 ohms	10.0 kHz
100 ohms	6.7 kHz
200 ohms	5.0 kHz
500 ohms	2.9 kHz
1000 ohms	1.7 kHz

Refer to the paragraphs on "Relay Modules" later in this chapter for information on modification of the filter characteristics.

INPUT IMPEDANCE

Open Channel: > 100 megohm, shunted by 3 pf

Closed Channel: > 1 megohm all ranges, 50 pf shunt

Power Off: > 100 megohm, 3 pf shunt

Table 7-1. HP 25504 Specifications (Continued)

INPUT OVERLOAD PROTECTION

1 to 100 Gain Range*: (Overload occurs at +/- 12 volts) steady state up to 350 volts

0.1 Gain Range: Steady state up to 250 volts; power off to 350 volts

* The HP 25504 includes an overload circuit that opens the relay of the selected channel when a potential greater than 12 volts is applied. The returned analog data will indicate full-scale overrange. Overload recovery requires initiating a new reading on the addressed channel.

ACCURACY

Static Accuracy (at 25 degrees C without autocalibrate cycle):

Input Channel Range	% of Full Scale Referred to Input (+/- 1/2 LSB)	Volts Referred to Input (+/- 1/2 LSB)
+/- 100 V	+/- 0.05 %	50.0 mV
+/- 10 V	+/- 0.05 %	5.0 mV
+/- 1 V	+/- 0.05 %	500 uV
+/- 0.1 V	+/- 0.05 %	50 uV

Table 7-1. HP 25504 Specifications (Continued)

Temperature Coefficients:

Input Channel Range	Offset Temperature Coefficient Referred to Input	Gain Temperature Coefficient Referred to Input
+/- 100	0.0007%/degree C 700 uV/degree C	+/- 0.004%/degree C
+/- 10	0.0007%/degree C 70 uV/degree C	+/- 0.004%/degree C
+/-1	.0.0025%/degree C 25 uV/degree C	+/- 0.004%/degree C
+/- 0.1	0.02%/degree C 20 uV/degree C	+/- 0.004%/degree C

Static Offset

Input Channel	Accuracy Referred to Input	
+/- 100	0.0005%	500 uV
+/- 10	0.0005%	50 uV
+/- 1	0.005%	50 uV
+/- 0.1	0.05%	50 uV

AC ACCURACY

Full Power Bandwidth (with 0 ohms input impedance):

Input Channel Range	Bandwidth
+/- 100	1 kHz
+/- 10	1 kHz
+/- 1	1 kHz
+/- 0.1	1 kHz

Table 7-1. HP 25504 Specifications (Continued)

Small Signal Bandwidth (with 0 ohms input impedance):

Input Channel Range	Bandwidth
+/- 100	10 kHz
+/- 10	10 kHz
+/- 1	10 kHz
+/- 0.1	5 kHz

NOISE

Input Channel Range	uV RMS Referred to Input	uV Peak
+/- 100	1000	3000
+/- 10	500	1500
+/- 1	100	300
+/- 0.1	15	45

PHYSICAL CHARACTERISTICS:

Width: 28.91 cm (11.38 in.)

Depth: 34.8 cm (13.54 in.)

Height: 3.5 cm (1.38 in.)

Weight: 680 grams (1.5 lbs)

7.4 FUNCTIONAL DESCRIPTION

Figure 7-2 is a functional block diagram diagram showing the input/output buses and the major functions of the RLYMUX.

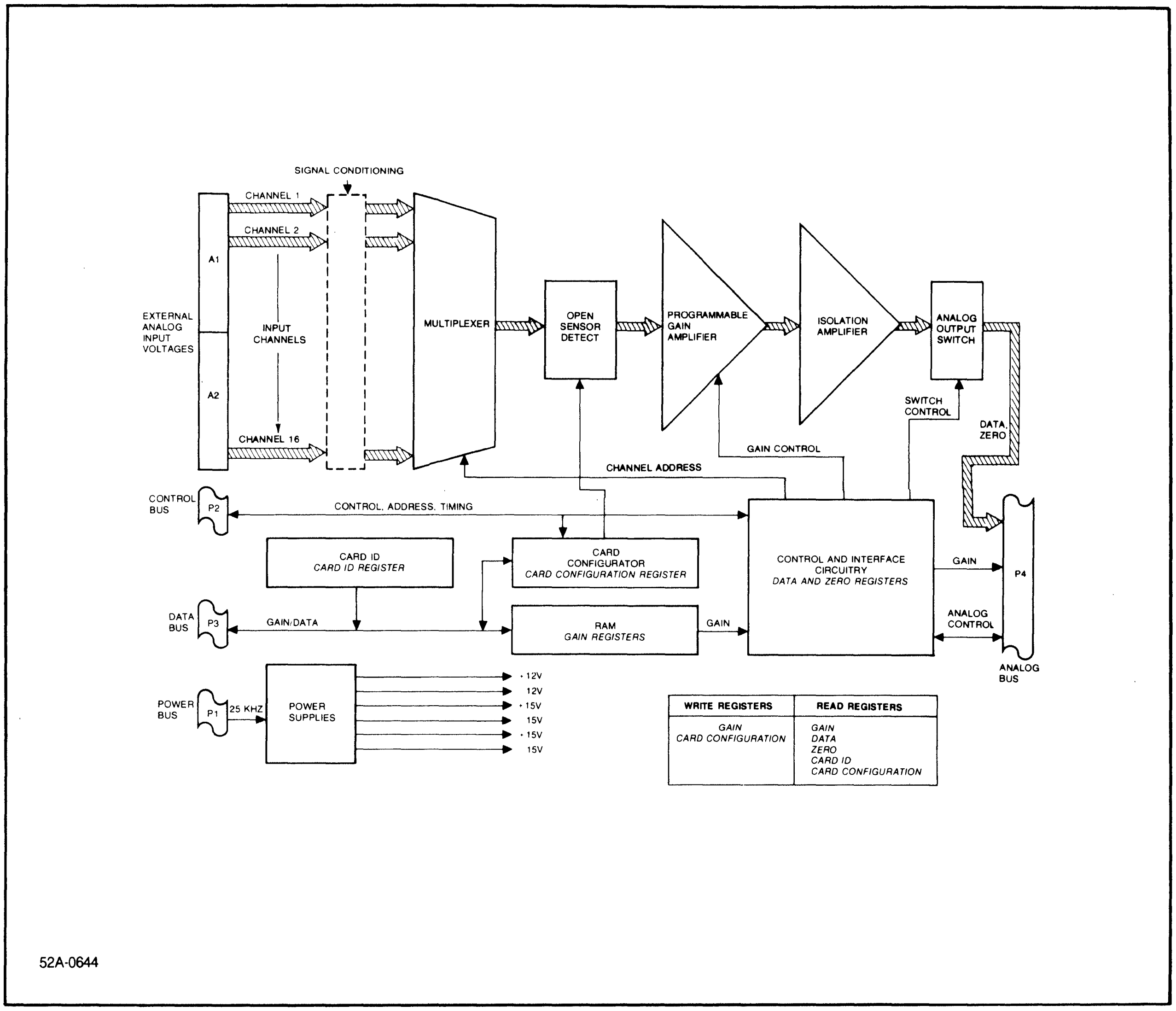


Figure 7-2. HP 25504 Functional Block Diagram

The RLYMUX, upon command from the processor unit (HP 2104), selects an analog input voltage, amplifies it, and transfers it to the HP 25501A 16-Channel High-Speed Analog Input (ADC) card. The ADC card converts the value of the analog voltage to an equivalent digital word and transfers it along with the system gain value to the HP 12071A Measurement and Control Interface (MCI) card.

Up to 16 channels can be connected directly to the input connectors on the RLYMUX, with each channel capable of providing an independent analog input voltage. Each input channel has a DATA register associated with it. An input channel is selected by addressing its associated DATA register. The selected analog input voltage passes through a Multiplexer and an Open Sensor Detect circuit to the input of the Programmable Gain Amplifier (PGA).

The Open Sensor Detect circuit is used to locate an open circuit or line in one of the input channels. It is turned on or off by setting or clearing bit 7 of the card configuration register (register 249). When the Open Sensor Detect circuit is turned on, the RLYMUX puts out a small current (6 microamperes) to check for an open circuit. If the circuit is open (an input line is broken or unplugged), the current feeding into the high resistance will drive the voltage to the overrange state and give a positive full-scale voltage reading. An open circuit will cause a full-scale reading on any gain range from 1 to 800. The Open Sensor Detect circuit does not work for gain less than 1.

An overrange condition will produce the same results as an open circuit. That is, if an overrange input voltage is applied, a full-scale reading will occur. To determine whether an overrange condition or an open circuit is causing the full-scale reading, turn off the Open Sensor Detect circuit and take another reading. If the input circuit is open, the voltage reading will drop to a low noise level; if the circuit is closed and an overrange voltage is present, the reading will remain at full scale.

Another condition that can approach or reach a full-scale reading is a high resistance (1500 ohms or greater) in the input circuit. When the 6 microampere current is applied to such a resistance, the voltage induced in the circuit can give a full-scale reading, especially in the higher gain ranges. You can distinguish this situation from an open circuit by reducing the gain and taking a reading: if the circuit is closed, the voltage reading will be less than full scale in the lower gain ranges; if the circuit is open, the voltage reading will remain at full scale in all gain ranges from 1 to 800.

If the voltage induced by the 6 microampere current contaminates your reading excessively, you can turn on the Open Sensor Detect circuit to check for an open circuit, and then turn it off to make the actual reading.

Each input channel has an associated GAIN register. Each of these GAIN registers can be programmed to one of the following gains: .1, 1, 10, or 100. Also gains of 1, 2, 4, 8, and autoranging can be programmed, which are used to set the gain of the ADC card PGA. When a reading is requested from a specific channel, the contents of the associated GAIN register automatically set the gain of the RLYMUX and ADC card PGA to the programmed value. At any time, through programming, you can read or change the contents of the GAIN registers.

After amplification in the PGA, the analog voltage passes through the Isolation Amplifier. The Isolation Amplifier contains a pulse transformer which magnetically isolates the input grounds from those of the rest of the system. The analog voltage then passes through the closed Analog Output Switch to the ADC card. The gain data from the associated GAIN register is also sent to the ADC card when a read DATA is requested, to set the gain of the ADC card PGA.

7.5 RELAY MODULES

7.5.1 GENERAL DESCRIPTION

The relay modules of the RLYMUX card provide the relay switching for the input signals attached to the card. The RLYMUX card contains 16 relay modules, one for each input channel. Each relay module is connected to the card by a series of connection pins, and is held in place by two screws.

The locations of the relay modules are shown in figure 7-3. An individual relay module is shown later, in figure 7-4. The relays modules are numbered sequentially from 1 to 16. Refer to the paragraphs on "Pin Assignments and Cabling", later in this chapter, for the pin assignments of the corresponding channels.

The relays on the relay modules have a finite life, averaging 40 million closures. (Actual relay lifetime is a function of the common mode voltage applied, and varies between 10 million and 100 million closures. 40 million closures is an average figure.) Because applications involving high frequency switching can use up the expected life of a relay in a relatively short time, the relay modules are designated as "replaceable by the customer". The following paragraphs describe the procedure for removing and replacing defective relay modules. The paragraphs on "Relay Verification", at the end of this chapter, provide a procedure for detecting defective relay modules.

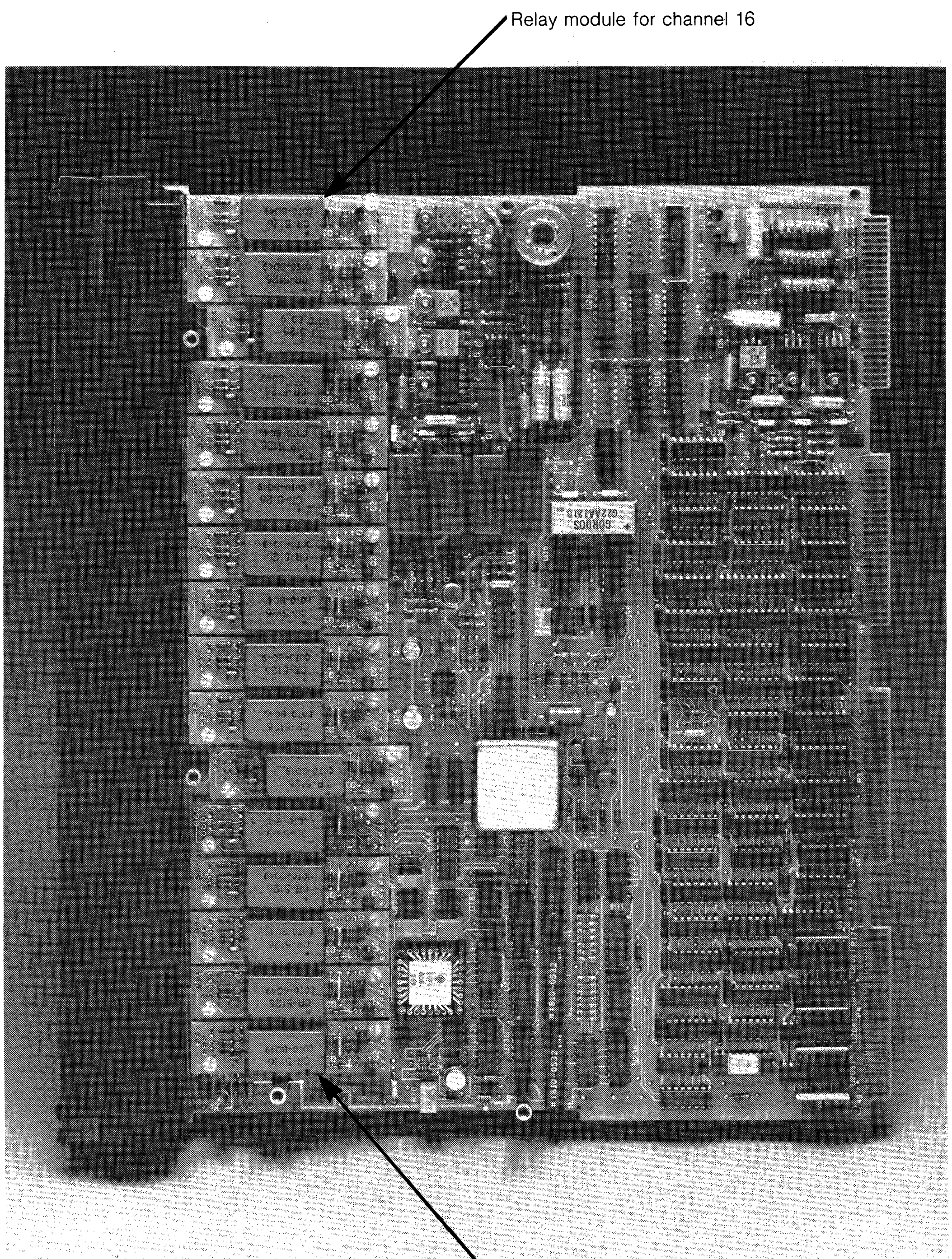


Figure 7-3. Locations of Relay Modules

7.5.2 REMOVAL AND REPLACEMENT

Use the following procedure to remove a relay module from the RLYMUX card and replace it with another relay module.

1) Turn the power to the HP 2250 system OFF.

WARNING

High voltages (up to 350 volts) may be present in the field wiring assemblies (FWAs). Such voltages are potentially lethal. When you disconnect the FWAs from the RLYMUX card, be careful that you do not establish a path from the FWA to ground, particularly through yourself. Be sure to place the FWAs in a position that prevents them from becoming grounded.

2) Disconnect the FWAs from the RLYMUX card.

CAUTION

The RLYMUX card contains static-sensitive components. Be sure to use appropriate anti-static procedures when you handle the card. (The pages on "Safety Considerations" at the beginning of this manual describe the anti-static procedures that you should follow.) Failure to follow these procedures may result in damage to the card.

3) Remove the RLYMUX card from its slot and place it on a static-free work surface.

NOTE

A label on the shield warns of hazardous voltages. This warning refers to the voltages that may be present at the FWAs. As long as the FWAs remain unconnected, hazardous voltages are not present on the RLYMUX card.

4) Unscrew the five screws that secure the metal shield to the top of the RLYMUX card, and remove the shield.

CAUTION

The connector pins that connect the relay modules to the RLYMUX card are easily damaged. Be careful not to damage these pins when removing or installing the relay module.

5) Unscrew the two screws securing the relay module that you wish to remove. Carefully remove the module from the connection pins.

6) Carefully install the new relay module on the connection pins and secure it with the two screws.

7) Replace the metal shield on top of the RLYMUX card and secure it with the five screws.

8) Using the appropriate anti-static procedures, replace the RLYMUX card in its slot in the HP 2250.

WARNING

Hazardous or lethal voltages may be present in the field wiring assemblies (FWAs) of the RLYMUX card. When you handle these FWAs, be careful not to create a path from the FWAs to ground.

9) Connect the FWAs to the RLYMUX card.

10) Turn the HP 2250 system power ON and make sure that the system passes self-test.

This completes the relay module removal and replacement procedure. The HP 2250 is once again ready for operation.

7.5.3 MODIFICATION OF FILTER CHARACTERISTICS

There is a 10 kHz low pass input filter on each relay module. This filter has the characteristics described in the section on "Source Impedance" in table 7-1; the bandwidth is sharply curtailed when a high-impedance sensor is used.

It is possible to obtain the full 10 kHz single-channel bandwidth when using a high-impedance sensor, at the cost of increased noise in the circuit. To accomplish this, take a relay module and remove the 0.1 microfarad capacitor (shown in figure 7-4) from it; then install the relay module on the appropriate channel in accordance with the removal and replacement procedure outlined above.

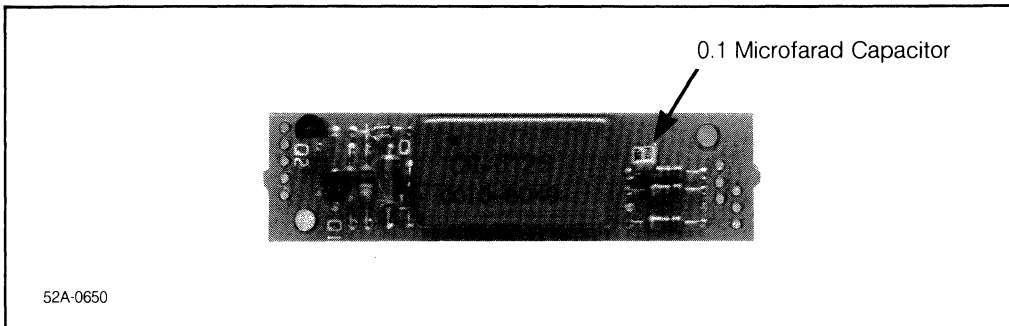


Figure 7-4. Modification to Relay Module (refer to text)

7.6 REGISTER ASSIGNMENTS

Register assignments for the RLYMUX card are shown in figure 7-2.

The analog input cards (ADC and multiplexers) all have the same register assignments. The raw data returned from the card is in double word format. The register assignments allow for future expansion up to 48 channels per card.

To read the zero-reference voltage on a channel, read from the appropriate register on pages 9-11. Programming the gain for a channel is done by writing to the registers on pages 13-15.

The meaning of the configuration word of the analog input cards varies from card to card. For the RLYMUX card, the following meanings apply:

Bit	Meaning
7	1 - Open sensor detection on
	0 - Open sensor detection off

A read of the card status register always will return 0.

TABLE 7-2. ANALOG INPUT REGISTER ASSIGNMENTS

	PAGE 1 word 1	PAGE 1 word 2	PAGE 2 word 1	PAGE 2 word 2	PAGE 3 word 1	PAGE 3 word 2	PAGE 4 word 1	PAGE 4 word 2
	1st	2nd	1st	2nd	1st	2nd		
1	DATA1	GAIN1	DATA17	GAIN17	DATA33	GAIN33		
2	DATA2	GAIN2	DATA18	GAIN18	DATA34	GAIN34		
3	DATA3	GAIN3	DATA19	GAIN19	DATA35	GAIN35		
4	DATA4	GAIN4	DATA20	GAIN20	DATA36	GAIN36		
5	DATA5	GAIN5	DATA21	GAIN21	DATA37	GAIN37		
6	DATA6	GAIN6	DATA22	GAIN22	DATA38	GAIN38		
7	DATA7	GAIN7	DATA23	GAIN23	DATA39	GAIN39		
8	DATA8	GAIN8	DATA24	GAIN24	DATA40	GAIN40		
9	DATA9	GAIN9	DATA25	GAIN25	DATA41	GAIN41		
10	DATA10	GAIN10	DATA26	GAIN26	DATA42	GAIN42		
11	DATA11	GAIN11	DATA27	GAIN27	DATA43	GAIN43		
12	DATA12	GAIN12	DATA28	GAIN28	DATA44	GAIN44		
13	DATA13	GAIN13	DATA29	GAIN29	DATA45	GAIN45		
14	DATA14	GAIN14	DATA30	GAIN30	DATA46	GAIN46		
15	DATA15	GAIN15	DATA31	GAIN31	DATA47	GAIN47		
16	DATA16	GAIN16	DATA32	GAIN32	DATA48	GAIN48		

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1				
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7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

TABLE 7-2. ANALOG INPUT CARD REGISTER ASSIGNMENTS, CONTINUED

	PAGE 9 word 1	PAGE 9 word 2	PAGE 10 word 1	PAGE 10 word 2	PAGE 11 word 1	PAGE 11 word 2	PAGE 12 word 1	PAGE 12 word 2
1	ZERO1	GAIN1	ZERO17	GAIN17	ZERO33	GAIN33		
2	ZERO2	GAIN2	ZERO18	GAIN18	ZERO34	GAIN34		
3	ZERO3	GAIN3	ZERO19	GAIN19	ZERO35	GAIN35		
4	ZERO4	GAIN4	ZERO20	GAIN20	ZERO36	GAIN36		
5	ZERO5	GAIN5	ZERO21	GAIN21	ZERO37	GAIN37		
6	ZERO6	GAIN6	ZERO22	GAIN22	ZERO38	GAIN38		
7	ZERO7	GAIN7	ZERO23	GAIN23	ZERO39	GAIN39		
8	ZERO8	GAIN8	ZERO24	GAIN24	ZERO40	GAIN40		
9	ZERO9	GAIN9	ZERO25	GAIN25	ZERO41	GAIN41		
10	ZERO10	GAIN10	ZERO26	GAIN26	ZERO42	GAIN42		
11	ZERO11	GAIN11	ZERO27	GAIN27	ZERO43	GAIN43		
12	ZERO12	GAIN12	ZERO28	GAIN28	ZERO44	GAIN44		
13	ZERO13	GAIN13	ZERO29	GAIN29	ZERO45	GAIN45		
14	ZERO14	GAIN14	ZERO30	GAIN30	ZERO46	GAIN46		
15	ZERO15	GAIN15	ZERO31	GAIN31	ZERO47	GAIN47		
16	ZERO16	GAIN16	ZERO32	GAIN32	ZERO48	GAIN48		

	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1	GAIN1	GAIN17	GAIN33	
2	GAIN2	GAIN18	GAIN34	
3	GAIN3	GAIN19	GAIN35	
4	GAIN4	GAIN20	GAIN36	
5	GAIN5	GAIN21	GAIN37	
6	GAIN6	GAIN22	GAIN38	
7	GAIN7	GAIN23	GAIN39	
8	GAIN8	GAIN24	GAIN40	
9	GAIN9	GAIN25	GAIN41	CARD CONFIG
10	GAIN10	GAIN26	GAIN42	0
11	GAIN11	GAIN27	GAIN43	CARD STATUS
12	GAIN12	GAIN28	GAIN44	0
13	GAIN13	GAIN29	GAIN45	CARD ID REG
14	GAIN14	GAIN30	GAIN46	0
15	GAIN15	GAIN31	GAIN47	0
16	GAIN16	GAIN32	GAIN48	BIF

7.7 PIN ASSIGNMENTS AND CABLING

Table 7-3 shows the signals that are routed to the card connector pins on the edge of the card. The connector numbering scheme is shown in figure 3-11, at the end of Section III of this manual.

Table 7-3. HP 25504A I/O Connector Module Pin Assignments

CONNECTOR	PINS	CONNECTION	CONNECTOR	PINS	CONNECTION
A1J1	1,2	ID Resistor	A3J1	1,2	ID Resistor
A1J1	2	Ground	A3J1	2	Ground
A1J1	3	Thermocouple Supply (+)	A3J1	3	Thermocouple Supply (+)
A1J1	4	Thermocouple Supply (-)	A3J1	4	Thermocouple Supply (-)
A1J2	1-4	Channel 1	A3J2	1-4	Channel 9
A1J3	1-4	Card guard	A3J3	1-4	Card guard
A1J4	1-4	Channel 2	A3J4	1-4	Channel 10
A1J5	1-4	Card guard	A3J5	1-4	Card guard
A1J6	1-4	Channel 3	A3J6	1-4	Channel 11
A1J7	1-4	Card guard	A3J7	1-4	Card guard
A1J8	1-4	Channel 4	A3J8	1-4	Channel 12
A1J9	1-4	Card guard	A3J9	1-4	Card guard
A2J1	1-4	Card guard	A4J1	1-4	Card guard
A2J2	1-4	Channel 5	A4J2	1-4	Channel 13
A2J3	1-4	Card guard	A4J3	1-4	Card guard
A2J4	1-4	Channel 6	A4J4	1-4	Channel 14
A2J5	1-4	Card guard	A4J5	1-4	Card guard
A2J6	1-4	Channel 7	A4J6	1-4	Channel 15
A2J7	1-4	Card guard	A4J7	1-4	Card guard
A2J8	1-4	Channel 8	A4J8	1-4	Channel 16
A2J9	1-4	Card guard	A4J9	1-4	Card guard

Note that pins 1 through 4 of the input channels have the following connections: Pin 1 (+ Input), Pin 2 (- Input), Pins 3 and 4 (Guard). The connectors labeled "card guard" are all connected to a card-driven guard.

The connection between the RLYMUX card and the field wiring is made with one of three cables:

HP 25551C (RLYMUX card cable with screw terminations)

HP 25551D (RLYMUX card cable, unterminated)

HP 25594B (RLYMUX card cable with thermocouple reference connector)

WARNING

> USE ONLY THE SPECIFIED CABLES (HP 25551C, HP 25551D, or HP 25594B) WHEN MAKING CONNECTIONS TO THE RLYMUX CARD. Do not attempt to use other cables. Due to differences in cable configuration, use of other cables could cause high common mode input voltages (up to 350 volts or more) to be routed to field wiring terminations where they are not expected. THESE HIGH COMMON MODE VOLTAGES CAN BE HAZARDOUS OR EVEN LETHAL. USE ONLY THE PROPER CABLES WITH THE RLYMUX CARD.

Note that the RLYMUX cables are NOT INTERCHANGEABLE with non-RLYMUX cables. As indicated in the warning above, the use of non-RLYMUX cables with the RLYMUX card could cause hazardous voltages to be routed to points where they are not expected. The use of RLYMUX cables with a non-RLYMUX card is not hazardous, but the differences in connector configurations will cause you to lose the use of at least half of the channels on the card.

7.8 CALIBRATION

If the RLYMUX card is not operating according to specifications, you may need to calibrate it. After calibration, you can verify the overall operation of the card by performing the tests described in the HP 2250 Measurement and Control Processor Diagnostic and Verification Manual, part number 25595-90001.

There are two parts to the calibration procedure for the RLYMUX card: linearity adjustment and offset adjustment. The linearity adjustment should be made before the offset adjustment. The following paragraphs contain specific instructions for calibrating the RLYMUX card.

7.8.1 EQUIPMENT REQUIRED

You will need the following equipment to calibrate the RLYMUX card.

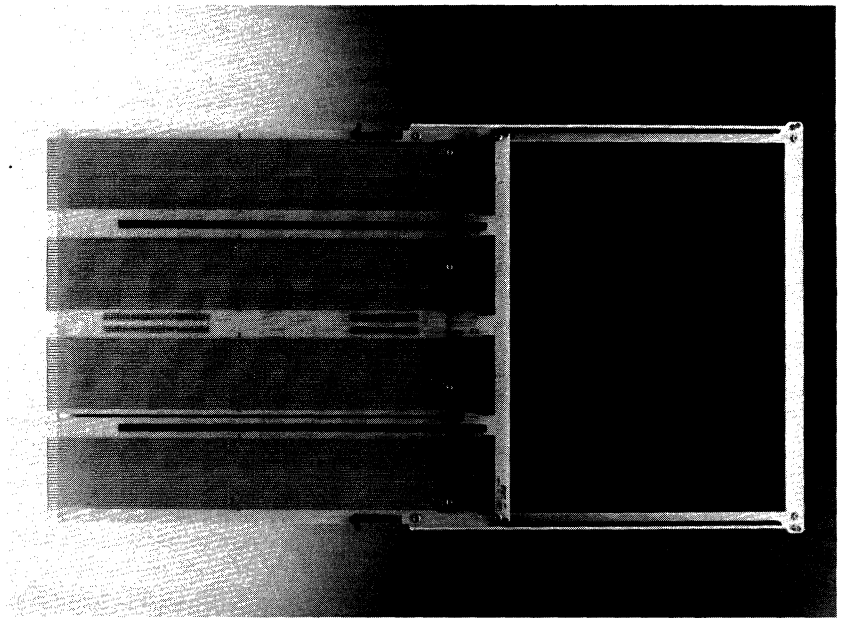
1) A digital voltmeter capable of resolving 100 microvolts on a ± 10 volt scale. The HP 3455A, 3456A, and 3490A digital voltmeters will do the job.

2) An accurate DC voltage source, capable of outputting ± 9 volts with an error of less than 1 millivolt. The model 501 J voltage source from Electronic Development Corporation is one such instrument.

3) Extender card, part number 25591-60001, as shown in figure 7-5.

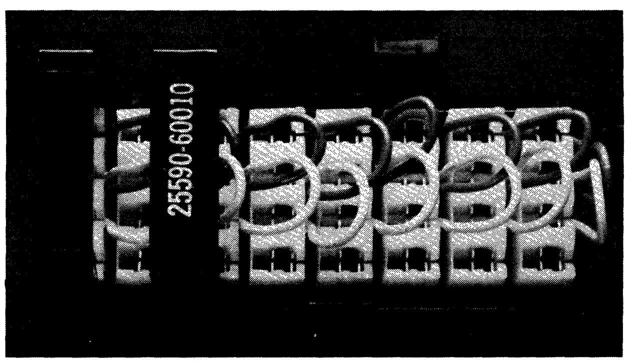
4) Shorting connector, part number 25590-60010, as shown in figure 7-6.

In addition, if the MCX exerciser program is available on your host computer, you will probably find it useful for issuing MCL/50 commands to the RLYMUX card during the calibration procedure.



52A-0632

Figure 7-5. Extender card



52A-0631

Figure 7-6. Shorting connector

7.8.2 PRELIMINARY PROCEDURE

1) Turn the power to the HP 2250 system OFF.

WARNING

High voltages (up to 350 volts) may be present in the field wiring assemblies (FWAs). Such voltages are potentially lethal. When you disconnect the FWAs from the RLYMUX card, be careful that you do not establish a path from the FWA to ground, particularly through yourself. Be sure to place the FWAs in a position that prevents them from becoming grounded.

2) Disconnect the FWAs from the RLYMUX card.

CAUTION

The RLYMUX card contains static-sensitive components. Be sure to use appropriate anti-static procedures when you handle the card. (The pages on "Safety Considerations" at the beginning of this manual describe the anti-static procedures that you should follow.) Failure to follow these procedures may result in damage to the card.

3) Remove the RLYMUX card from its slot and insert the extender card in its place.

NOTE

A label on the shield warns of hazardous voltages. This warning refers to the voltages that may be present at the FWAs. As long as the FWAs remain unconnected, hazardous voltages are not present on the RLYMUX card.

4) Unscrew the five screws that secure the metal shield to the top of the RLYMUX card, and remove the shield. All adjustments will be made with the shield off.

5) Insert the RLYMUX card into the extender card. Leave the FWAs disconnected.

6) Turn the power to the HP 2250 system ON and make sure that the system passes self-test. (The self-test is described in the HP 2250 Installation and Start-Up Manual, part number 02250-90012.)

7) Allow the RLYMUX card to reach normal operating temperature. This warm-up period usually takes 15 minutes; if, however, the card was already at operating temperature before you turned the power off, and if the power was not off for more than 2 minutes, you can go ahead with the calibration procedure after the card has warmed up for 5 minutes.

8) Note the position of the slide switch on the front edge of the RLYMUX card; then set it to the ON position. (This ties the GUARD pins of the card to the LOW pins. After the calibration is finished, you will return the switch to its original position.)

9) At the host computer you are using (HP 1000, HP 9826, etc.) issue the command

   ```
   ID(1,n)!
   ```

   to your HP 2250, where n is the number of function card slots in your HP 2250 system. (If you are using the MCX exerciser program, just type in "CARDS".) This will cause the ID codes of the function cards in your system to be returned; an ID code of 4 should be returned for the slot that contains the HP 25504 RLYMUX card.

10) Issue the following command from the host computer to the HP 2250:

    AI(slot,1)

    where "slot" is the slot number of the RLYMUX card. This will cause the HP 2250 to make an analog reading of the RLYMUX card. Two values should be returned:

    a) A condition code of 0, indicating that the command executed correctly.

    b) The datum from the conversion on channel 1; this should be any integer in the range of -32768 to 32767. (Since channel 1 is not connected to a known voltage, there is no way of knowing what the "correct" reading should be. All that you are doing here is verifying that the card is able to take a reading.)

11) If step 10 was successful (that is, if an integer between -32768 and 32767 was returned), you are ready to proceed with the calibration.

7.8.3 LINEARITY ADJUSTMENT

1) Select a channel and connect the leads from the voltage source to the high and low input pins for that channel. The polarity of this connection is not important. (The relationships between the channels and the input pins are described in the paragraphs on "Pin Assignments and Cabling", earlier in this chapter.

2) Connect the leads from the voltmeter to test points TP14 and TP15 on the RLYMUX card. (See figure 7-7.)

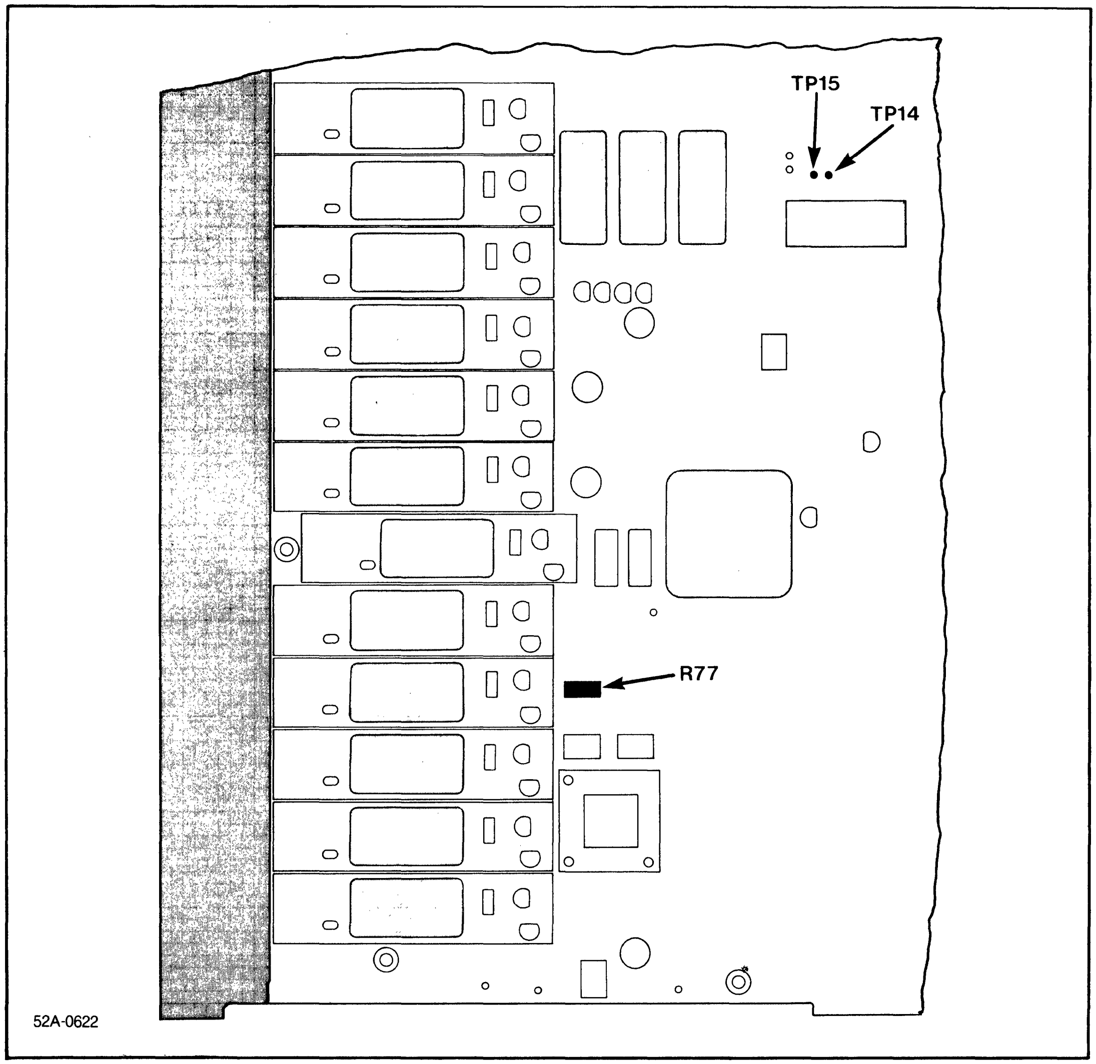


Figure 7-7. Linearity adjustment.

3) Set gain for the channel to 1. You can use the command

   GAIN (slot, channel) 98

   where "slot" specifies the number of the slot that contains the RLYMUX card that you are testing and "channel" specifies the number of the channel that you are using to make the measurements.

4) Take an analog reading from the channel. You can use the command

   AI (slot, channel)

   where "slot" specifies the number of the slot that contains the RLYMUX card that you are testing and "channel" specifies the number of the channel that you are using to make the measurements. This will connect the input pins to test points TP14 and TP15, and will allow the voltage supplied by the voltage source to be displayed on the voltmeter.

5) Set the voltage source to provide 9 volts and note the voltage reading that appears on the voltmeter. Then set the voltage source to provide -9 volts and again observe the reading on the voltmeter. The difference between the two voltage readings should be 18.000 V ± 0.001 V; if it is not, the card is out of linear calibration. Don't worry about voltage offset during this part of the calibration procedure; that will be covered next, in the paragraphs on offset adjustment.

   If the card is out of linear calibration, adjust potentiometer R77 (see figure 7-7) until the above test yields a voltage difference of 18.000 V ± 0.001 V.

6) Disconnect the voltage source and the voltmeter from the RLYMUX card.

7.8.4 OFFSET ADJUSTMENT

1) Select a channel and short the high and low input pins of that channel, using the shorting connector (shown in figure 7-6).

2) Set the gain of that channel to 100. You can use the command

   ```
   GAIN (slot, channel) 100
   ```

   where "slot" specifies the slot that contains the RLYMUX card and "channel" specifies the channel that you are using for this measurement.

3) Take a reading from the channel. Use the command

   ```
   AI (slot, channel)
   ```

   where "slot" specifies the slot that contains the RLYMUX card and "channel" specifies the channel that you are using for this measurement.

4) Connect the voltmeter leads to test points TP11 and TP20. (See figure 7-8.)

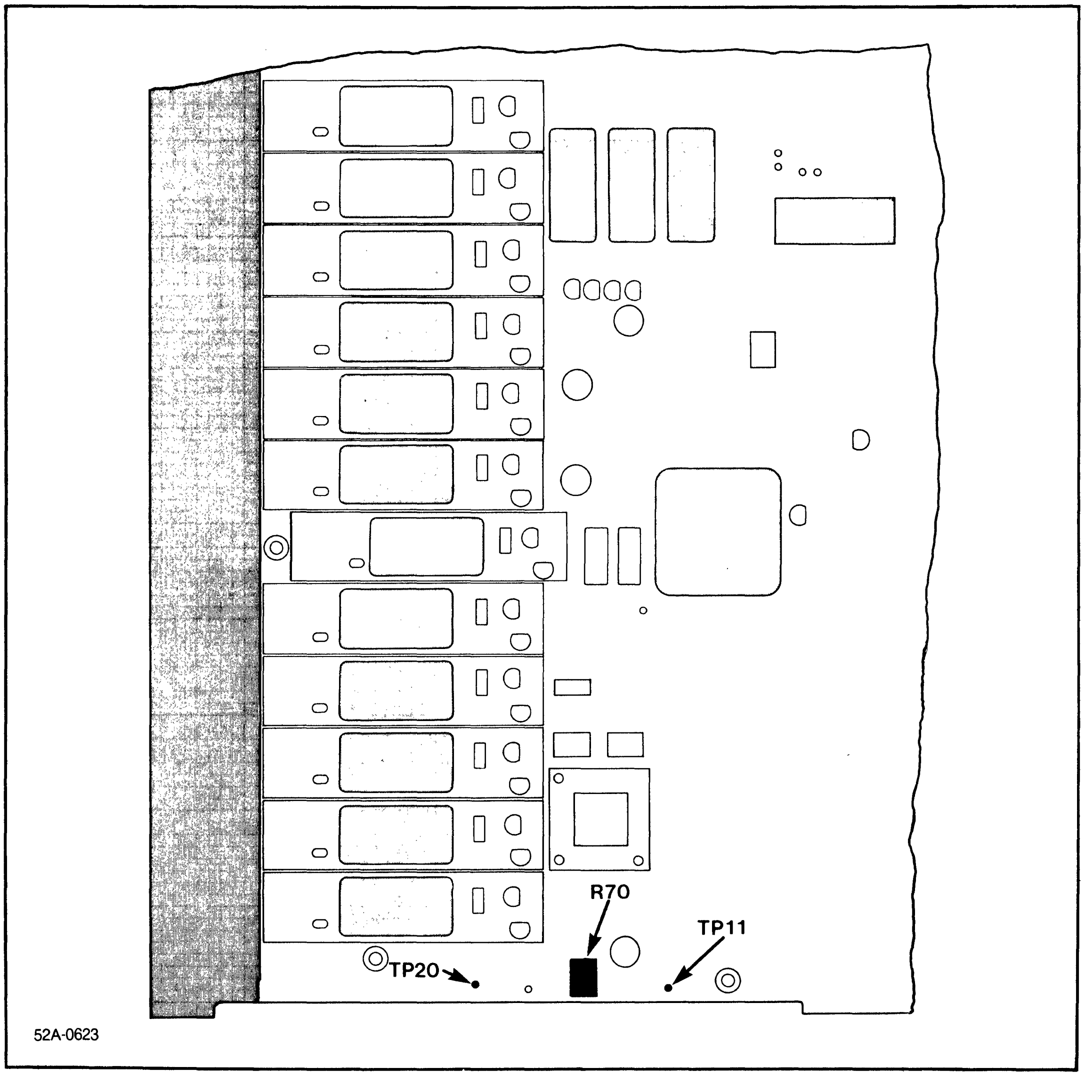


Figure 7-8. First Offset Adjustment

5) Adjust potentiometer R70 (see figure 7-8) until the voltage reading on the voltmeter is 0.0 mV ± 0.2 mV. (The voltage reading will change continuously to some small degree. This noise is normal and should not be of concern as long as it is possible to obtain a continuous offset within the 0.0 mV ± 0.2 mV range.)

6) Remove the voltmeter lead from test point TP11 and connect it to test point TP10. Leave the other voltmeter lead connected to test point TP20. (See figure 7-9.)

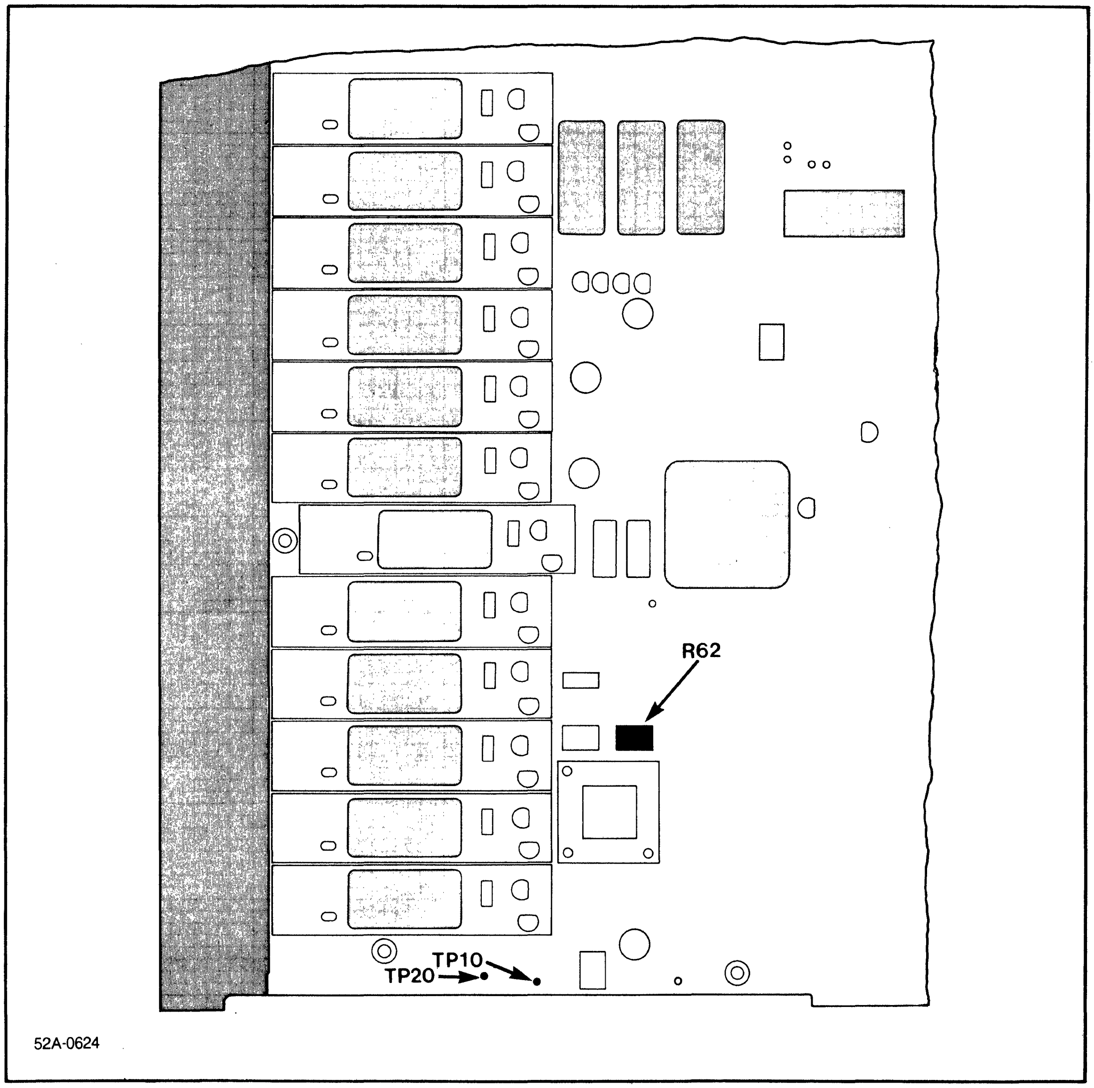


Figure 7-9. Second Offset Adjustment

7) Adjust potentiometer R62 (see figure 7-9) until the voltage reading on the voltmeter is 0.0 mV ± 0.2 mV. (As with the first offset adjustment, there will be some noise present.)

8) Remove the voltmeter leads from the test points and connect them to test points TP14 and TP15. (See figure 7-10.)

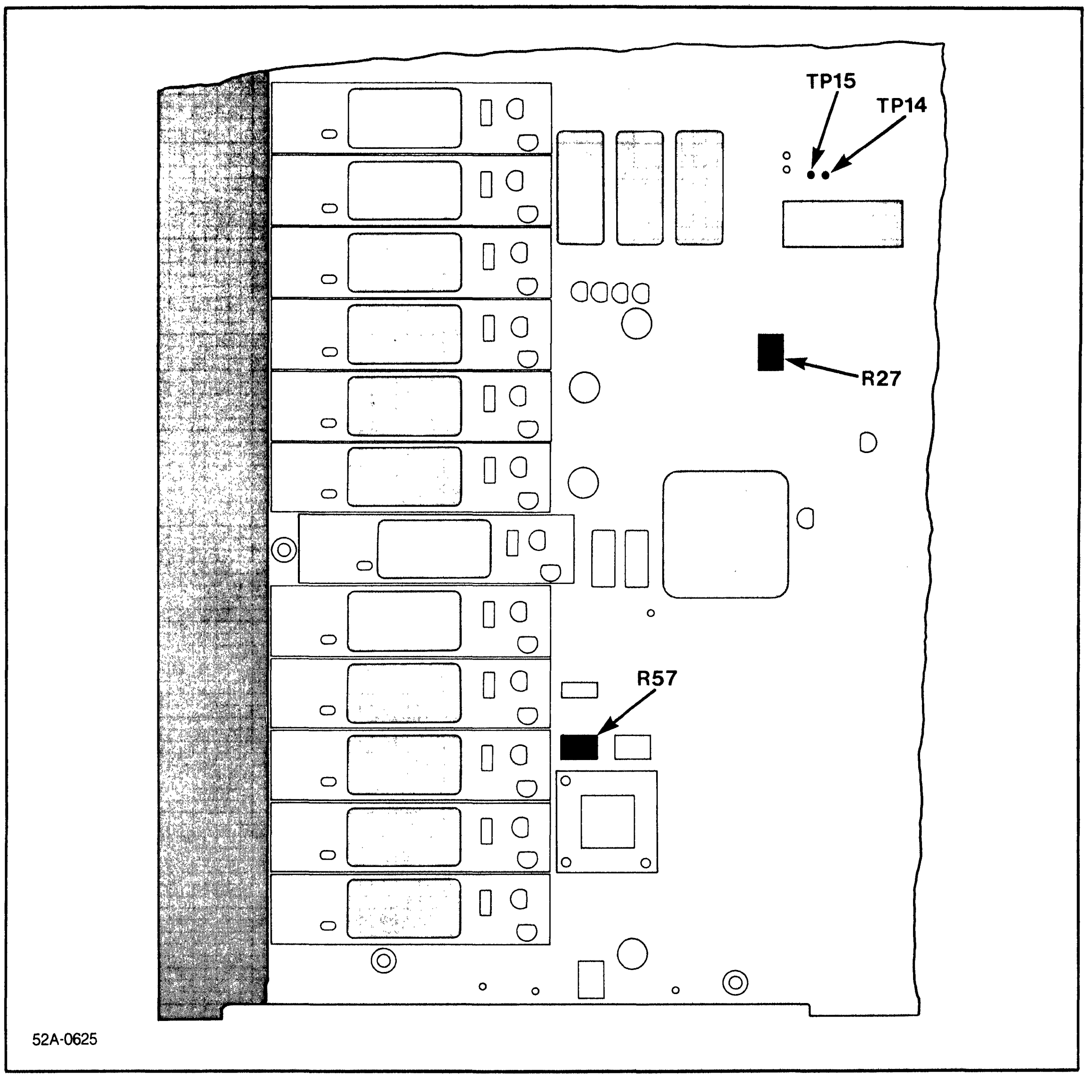


Figure 7-10. Third Offset Adjustment

9) Adjust potentiometers R27 and R57 until the voltage reading on the voltmeter is 0.0 mV $\pm$ 0.2 mV. While it is usually possible to make this adjustment using only one of the potentiometers, it is better to adjust both potentiometers together, a little at a time, until you obtain the proper reading. (As with the first two adjustments, there will be a certain amount of noise. This noise is normal and should not be of concern as long as it does not prevent you from calibrating the card.)

10) Disconnect the voltmeter leads from the RLYMUX card, and remove the shorting connector from the card.

7.8.5 PUTTING THE SYSTEM BACK TOGETHER

Once you have made the linearity and offset adjustments, all that remains is to return the system to its normal operating configuration.

1) Turn the HP 2250 system power OFF.

CAUTION

The RLYMUX card contains static-sensitive components. Be sure to use appropriate anti-static procedures when you handle the card. (The pages on "Safety Considerations" at the beginning of this manual describe the anti-static procedures that you should follow.) Failure to follow these procedures may result in damage to the card.

2) Remove the RLYMUX card from the extender card and attach the metal shield to the RLYMUX card.

WARNING

High voltages (up to 350 volts) may be present in the field wiring assemblies (FWAs). Such voltages can be lethal. When you connect the FWAs to the RLYMUX card, be careful that you do not establish a path from the FWAs to ground, either through the equipment or through yourself.

4) Connect the field wiring assemblies (FWAs) to the RLYMUX card.

5) Set the slide switch at the front edge of the card to its original position.

6) Turn the HP 2250 system power ON and make sure that the system passes self-test.

7) The HP 2250 is now ready to return to normal operation.

7.9 RELAY VERIFICATION

The relays on the relay modules have a finite life, averaging 40 million closures. If a relay fails, it can fail in one of two modes: broken and left in the open position or stuck in the closed position. The symptoms of relay failure can be quite subtle; the most common symptoms are readings that give you unexpected values.

The procedures in the following paragraphs allow you to find out whether any of the input relays on your RLYMUX card have failed. Replace any failed relays, using the procedure outlined in the paragraphs on "Relay Modules", above.

The relay verification can be performed with the RLYMUX card in the HP 2250.

Channel assignments for the relay modules and the connector pins on the card edge are given earlier in this section.

7.9.1 EQUIPMENT REQUIRED

You will need the following equipment to perform the relay verification.

1) A voltage source. This could be the voltage source that you use for calibrating the RLYMUX card (Electronic Development Corporation model 501J, or equivalent), or it could even be a battery of known voltage.

2) A voltmeter capable of measuring volts and ohms. This could be the HP 3455 (or equivalent) that you use for calibrating the RLYMUX, or it could be any multimeter, such as the HP 3476A/B.

3) A program that allows you to issue commands to the HP 2250. The MCX program (part of the HP 25581 or HP 25582 Automation Library) is probably the easiest to use.

4) You might find specially wired connectors or standard unterminated cables (HP 25551D) to be handy. You will have to make connections to the individual pins of the card connectors, and there is not a lot of room to make connections at the pins themselves.

7.9.2 PRELIMINARY PROCEDURE

Take the following steps to prepare for the relay verification tests:

1) Turn the HP 2250 power OFF.

WARNING

High voltages (up to 350 volts or more) may be present in the field wiring assemblies (FWAs). Such voltages are potentially lethal. When you disconnect the FWAs from the RLYMUX card, be careful that you do not establish a path from the FWA to ground, either through the equipment or through yourself. Be sure to place the FWAs in a position that prevents them from becoming grounded.

2) Disconnect the FWAs from the RLYMUX card.

3) Turn the HP 2250 power ON, and make sure that the HP 2250 passes its self-test. You are now ready to test the relays.

4) Note the position of the GUARD-to-LOW slide switch on the front edge of the RLYMUX card. You will need to return this switch to its original position at the end of the verification procedure.

7.9.3 TEST FOR BROKEN (OPEN) RELAYS

The following procedure tests for relays that are broken and left in the open position. Any bad relays that you find should be replaced, using the procedures outlined in the paragraphs on "Relay Modules" earlier in this section.

1) Set the GUARD-to-LOW slide switch on the front of the card to the OFF position.

2) Using MCX or a similar program, set the gain of the RLYMUX card to a range that is compatible with your voltage source.

3) For each channel of the RLYMUX card:

   a) Connect the leads of the voltage source to the HIGH and LOW pins of the channel.

   b) Using a BLOCK AI command, take at least 50 readings of the voltage applied to the channel. (The large number of readings ensures that the voltage has time to settle at a stable value, even if it comes from a high-impedance source.)

c) Check that the value of the voltage reading is the same as the voltage supplied by the voltage source. If it is not the same, the relay module for the channel is bad and should be replaced.

d) Reverse the lead from the voltage source and take another 50 readings with a BLOCK AI command. Check that the value of the reading is the same as the voltage supplied by the source. If it is not the same, the relay module is bad and should be replaced.

e) Measure the resistance between the GUARD pin of the channel and an adjacent card-driven guard pin. The resistance should be approximately 100 ohms. If the resistance is very high (open circuit), the relay module is bad and should be replaced.

4) Go to the next channel and repeat the tests in step 3.

5) When all channels have been tested, this portion of the relay verification is complete. Go on to the test for relays stuck in the closed position.

7.9.4 TEST FOR STUCK (CLOSED) RELAYS

This procedure tests for relays that are stuck in the closed position. Any bad relays that you find should be replaced, using the procedures outlined in the paragraphs on "Relay Modules" earlier in this section.

Take the following steps:

1) Set the GUARD-to-LOW slide switch on the front of the RLYMUX card to ON.

2) Using MCX or a similar program, take a reading from channel 1 with an AI command.

3) Connect one lead of the ohmmeter to the HIGH pin of channel 1.

4) Using the other lead of the ohmmeter, check the resistance between the HIGH pin of channel 1 and the HIGH pins of each of the other channels, one channel at a time. Each channel should give a high resistance reading, indicating an open circuit. If you get a reading of approximately 200 ohms on any channel, the relay module for that channel is bad, and should be replaced.

5) Move the ohmmeter lead from the HIGH pin of channel 1 to the LOW pin of channel 1.

6) Using the other lead of the ohmmeter, check the resistance between the LOW pin of channel 1 and the LOW pins of each of the other channels, one channel at a time. Each channel should give a high resistance reading, indicating an open circuit. If you get a reading of approximately 200 ohms on any channel, the relay module

for that channel is bad, and should be replaced. (Note that this test checks the GUARD pins as well, since they are tied to the LOW pins through the GUARD-to-LOW switch.)

You have now tested all relays except the relay on channel 1. To test the channel 1 relay:

7) Connect one lead of the ohmmeter to the HIGH pin of channel 16.

8) Take a reading from channel 16 with an AI command.

9) Measure the resistance between the HIGH pin of channel 16 and the HIGH pin of channel 1. You should get a high resistance reading, indicating an open circuit. If you get a reading of approximately 200 ohms, the relay is bad, and should be replaced.

10) Move the ohmmeter lead from the HIGH pin of channel 16 to the LOW pin of channel 16.

11) Measure the resistance between the LOW pin of channel 16 and the LOW pin of channel 1. You should get a high resistance reading, indicating an open circuit. If you get a reading of approximately 200 ohms, the relay is bad, and should be replaced.

This completes the test for relays stuck in the closed position.

7.9.5 RECONNECTING THE FIELD WIRING

When you have finished testing for bad relays, take the following steps to reconnect the field wiring to the RLYMUX card.

1) Replace any relays that failed the tests, in accordance with the replacement procedure outlined in the paragraphs on "Relay Modules" earlier in this chapter.

2) Set the GROUND-to-LOW slide switch on the front of the RLYMUX card to its original position.

3) Turn the HP 2250 system power OFF.

WARNING

High voltages (up to 350 volts or more) may be present in the field wiring assemblies (FWAs). Such voltages can be lethal. When you connect the FWAs to the RLYMUX card, be careful that you do not establish a path from the FWAs to ground, either through the equipment or through yourself.

4) Connect the FWAs to the RLYMUX card.

5) Turn the HP 2250 system power ON and make sure that the system passes self-test.

The system is now ready for use.

Section VIII
HP 25510A 4-Channel Voltage/Current Analog Output

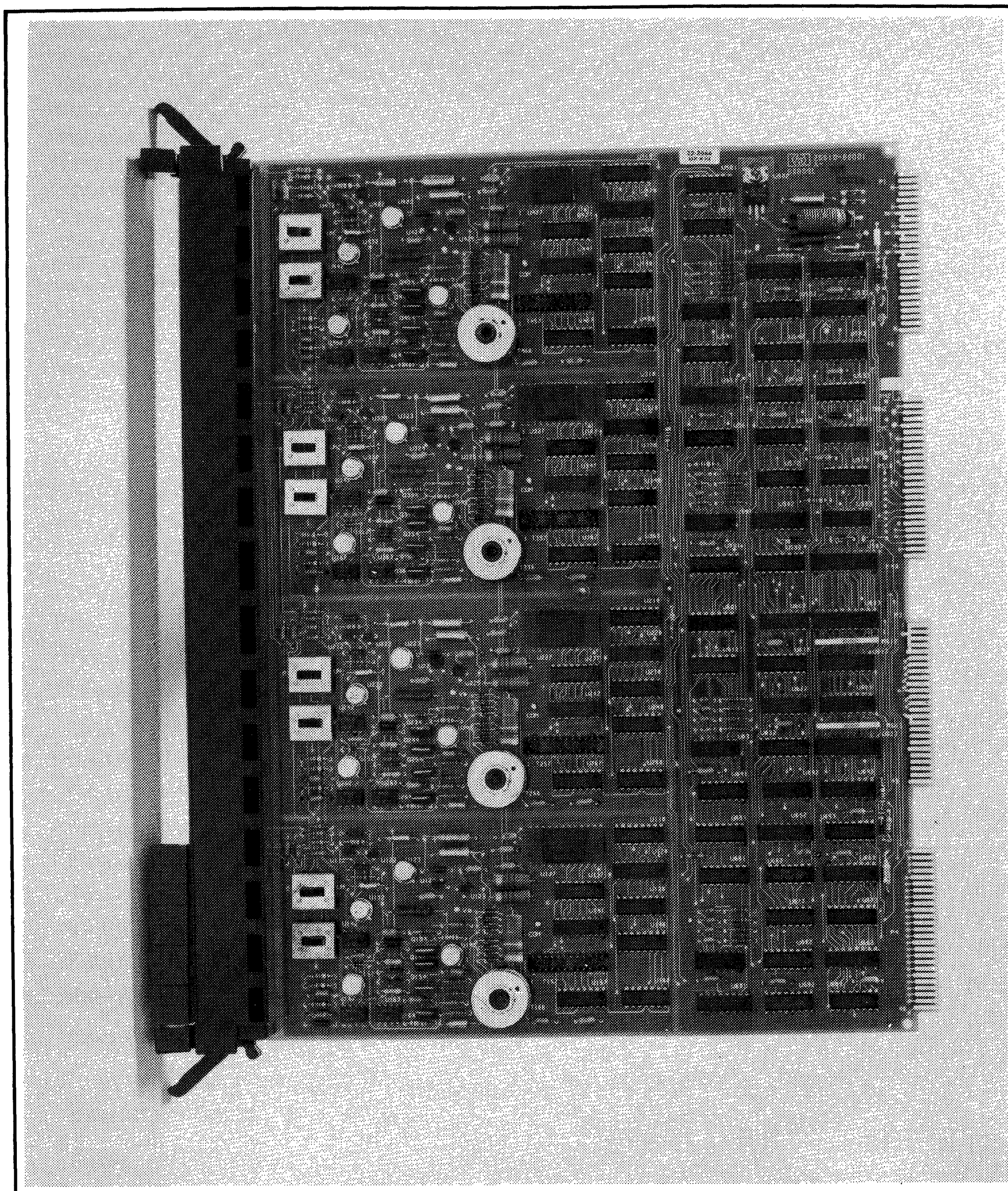
8.1 INTRODUCTION

This section provides information for the HP 25510A 4-Channel Voltage/Current Analog Output card. Included are specifications and a functional description. Installation information for the card is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

8.2 DESCRIPTION

The HP 25510A, shown in figure 8-1, provides the basic analog output capability for the HP 2250 system. The card features four programmable output channels. Each channel consists of a 12-bit digital-to-analog converter (DAC), and is isolated one from the other and from earth ground.

The channels can independently provide either a voltage or a current output, according to the switch settings of the voltage/current switches located on the card. A choice of either unipolar or bipolar output voltages is also provided for each channel by setting the unipolar/bipolar switches on the card to the desired position. Although the card will function properly without using remote sense, this feature is provided to allow increased accuracy when in the voltage output mode. Remote sense should not be used in the current output mode.



2250-89H

Figure 8-1. HP 25510A 4-Channel Voltage/Current Analog Output

8.3 SPECIFICATIONS

Table 8-1 contains specifications for the HP 25510A.

8.4 FUNCTIONAL DESCRIPTION

Figure 8-2 is a functional block diagram showing the input/output buses and the major functions of the HP 25510A card.

The primary purpose of the card is to convert the value of a data word received from the processor unit (HP 2104) to an equivalent analog voltage or current value and transfer it to the appropriate output channel.

The card has four isolated output channels capable of providing independent analog output voltages or currents for user applications. Each output channel has an OUTPUT CHANNEL Register associated with it. A write command selects the output channel by addressing its OUTPUT CHANNEL register.

When the card is programmed to output a voltage, an input data word from the processor containing the voltage value to be converted is applied to the input of the card's Formatter. The Formatter reformats the 16-bit input data word, rounds it off to a 12-bit word, and changes it from parallel to serial form. The output of the Formatter is applied to the input of a Channel Selector. The Channel Selector selects the proper channel when addressed by the Channel Address from the Control Logic.

Table 8-1. HP 25510A Specifications

FEATURES 12-bit resolution Four independent, isolated channels Unipolar or bipolar voltage output mode, or current output mode Remote sense capability (voltage output mode) Buffered voltage outputs 20 mA current output
APPLICATIONS Provides four output channels for proportional controllers, strip chart recorders, or any device controlled by either +/- 10 volt levels or a 20 mA current loop.
PROGRAMMING INFORMATION VO command: Voltage output to specified channel, in millivolts VOR command: Voltage output to specified channel, in floating point format (units are volts) CO command: Current output to specified channel, in microamps COR command: Current output to specified channel, in floating point format (units are amps) CONFIG command: Read output mode of all four channels of the selected card.

Table 8-1. HP 25510A Specifications (Continued)

ELECTRICAL CHARACTERISTICS			
Parameter	Current (uA)	Unipolar Voltage	Bipolar Voltage
Command	CO	VO	VO
Command Data Range (Integer)	0 to 20477	0 to 10238	-10240 to 10237
Output Range	0 to 20475 uA	0 to 10237.5 mV	-10240 to 10235 mV
Compliance	20 V	20 mA	+/- 20 mA
Resolution	5 uA	2.5 mV	5 mV
Accuracy (25 degrees C, less than 80% relative humidity)	+/- 5 uA	+/- 2.5 mV	+/- 5 mV
Accuracy Temperature Coefficient			
Below 80% relative humidity	+/- 0.4 uA/ degree C	+/- 0.2 mV/ degree C	+/- 0.4 mV/ degree C
80 to 95% relative humidity	+/- 0.8	+/- 0.4	+/- 0.8
Noise RMS (100 kHz bandwidth)	+/- 2 uA	+/1 1 mV	+/- 2 mV
Settling Time (-full scale to +full scale to within 1 LSB)	300 usec	100 usec	100 usec
Slew Rate	1 mA/usec	5 V/usec	5 V/usec
Output Protection	+/- 35 VDC across any current output	Short or +/- 15 VDC across any voltage output	

Table 8-1. HP 25510A Specifications (Continued)

ISOLATION:

400 volts peak (common mode)

DATA RATE (MAXIMUM):

31.25 K words/second

CROSSTALK (attenuation from channel to channel)

Frequency (kHz)	Attenuation (db)	Attenuation Ratio V(crosstalk)/V(noise ratio)
1	-82	0.00008
2	-77	0.00014
5	-60	0.001
10	-51	0.0028
20	-42	0.0079
50	-34	0.02
100	-29	0.035
200	-28	0.04

To calculate the actual crosstalk ratio:

V(crosstalk) = V(noise source) x attenuation ratio

Example:

The low side of an adjacent channel has 10 VAC, 50 kHz of noise. The voltage appearing differentially across the channel of interest is

10 x 0.02 = 200 mV, 50 kHz

Table 8-1. HP 25510A Specifications (Continued)

PHYSICAL CHARACTERISTICS	
Width:	28.91 cm (11.38 in.)
Depth:	34.8 cm (13.54 in.)
Height:	3.5 cm (1.38 in.)
Weight:	680 grams (1.5 lbs)

The data word from the Channel Selector then passes through the selected channel Isolation Transformer and is converted to an analog voltage by the 12-bit Digital-to-Analog Converter (DAC). From the DAC the analog voltage is sent to it associated output channel.

The output provides either a unipolar/bipolar voltage source or a current source, depending on the positions of the unipolar/bipolar and voltage/ current switches on the card.

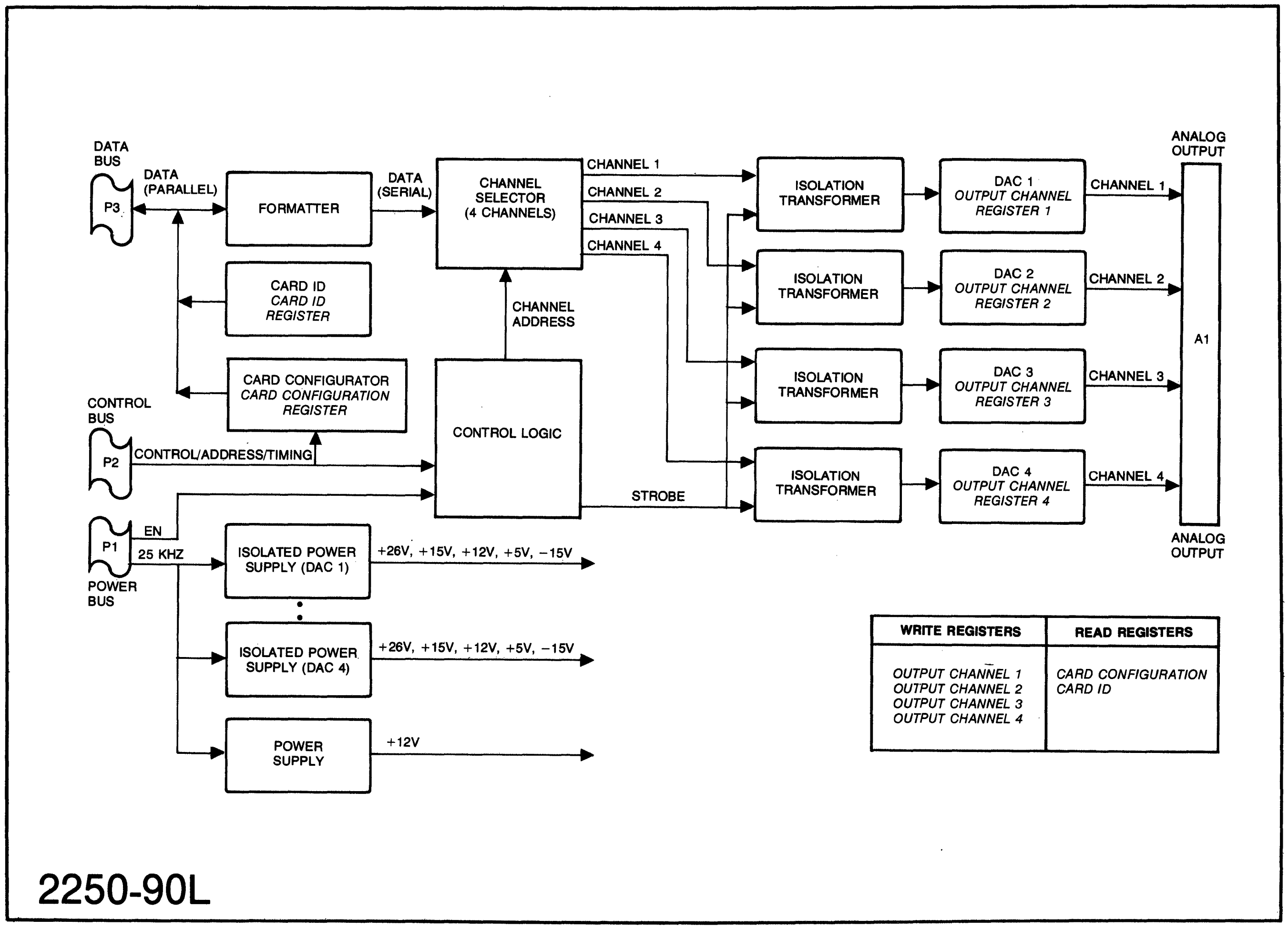


Figure 8-2. HP 25510A Functional Block Diagram

8.5 REGISTER ASSIGNMENTS

Register assignments for the DAC card are shown in table 8-2.

The analog output cards (DACs) perform no input. The data to be output is written to the registers on page 5. The output data is a 16 bit integer. The specific significance of each bit is:

Bit	Voltage mode	Current mode
15	sign bit	always set this to zero
14	5.120 V	10.240 mA
13	2.560 V	5.120 mA
12	1.280 V	2.560 mA
11	0.640 V	1.280 mA
10	0.320 V	0.640 mA
9	0.160 V	0.320 mA
8	0.080 V	0.160 mA
7	0.040 V	0.080 mA
6	0.020 V	0.040 mA
5	0.010 V	0.020 mA
4	0.005 V	0.010 mA
3	0.0025 V	0.005 mA
2	0.00125 V	0.0025 mA
1	unused	0.00125 mA
0	unused	unused

The card configuration register can be used to tell whether a channel is configured for bipolar voltage, unipolar voltage, or current output.

BIT	MEANING
0	Channel 1: Bipolar if set, Unipolar if Clear
1	Current output if set, Voltage if Clear
2	Channel 2: Bipolar/Unipolar
3	Current/Voltage
4	Channel 3: Bipolar/Unipolar
5	Current/Voltage
6	Channel 4: Bipolar/Unipolar
7	Current/Voltage
8-31	Undefined

A read of the card status register will always return 0.

TABLE 8-2. ANALOG OUTPUT REGISTER ASSIGNMENTS

	PAGE 1 (word 1 word 2)	PAGE 2 (word 1 word 2)	PAGE 3 (word 1 word 2)	PAGE 4 (word 1 word 2)
1 2 3 4 5 6 7 8				
9 10 11 12 13 14 15 16				

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1 2 3 4 5 6 7 8	OUTPUT CH. 1 OUTPUT CH. 2 OUTPUT CH. 3 OUTPUT CH. 4			
9 10 11 12 13 14 15 16				

TABLE 8-2. ANALOG OUTPUT CARD REGISTER ASSIGNMENTS, CONTINUED

	PAGE 9 (word 1 word 2)	PAGE 10 (word 1 word 2)	PAGE 11 (word 1 word 2)	PAGE 12 (word 1 word 2)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1				
2				
3				
4				
5				
6				
7				
8				
9				CARD CONFIG
10				0
11				CARD STATUS
12				0
13				CARD ID REG
14				0
15				0
16				BIF

8.6 PIN ASSIGNMENTS AND CABLING

Table 8-3 shows the signals that are routed to the card connector pins at the edge of the card. The connector numbering scheme is shown in figure 3-11, at the end of Section III of this manual.

Table 8-3. HP 25510A I/O Connector Module Pin Assignments

CONNECTOR	PINS	CONNECTION	CONNECTOR	PINS	CONNECTION
A1J1	1,2	ID Resistor	A1J6	1	Ch. 3, +V/I
A1J2	1	Ch. 1, +V/I	A1J6	2	Ch. 3, -V/I
A1J2	2	Ch. 1, -V/I	A1J7	1	Ch. 3, +S
A1J3	1	Ch. 1, +S	A1J7	2	Ch. 3, -S
A1J3	2	Ch. 1, -S	A1J8	1	Ch. 4, +V/I
A1J4	1	Ch. 2, +V/I	A1J8	2	Ch. 4, -V/I
A1J4	2	Ch. 2, -V/I	A1J9	1	Ch. 4, +S
A1J5	1	Ch. 2, +S	A1J9	2	Ch. 4, -S
A1J5	2	Ch. 2, -S			

V/I = voltage/current output
S = remote sense input

Note that pin 3 of J2 through J9 is not used by the Analog Output Card. Pin 3 is not electrically connected to the card, but may be used as a connection point for the shield in the HP 25551A/B I/O Cables.

The connection between the DAC card and the field wiring is made with one of two cables:

HP 25551A (analog card cable with screw terminations)

HP 25551B (analog card cable, unterminated)

8.7 CALIBRATION

The HP 25510 analog output card (DAC card) should be calibrated any time that you change the operating mode (unipolar voltage, bipolar voltage, or unipolar current output) of a channel, or after every nine months of operation under normal conditions. After calibration, you can verify the overall operation of the card by performing the tests described in the HP 2250 Measurement and Control Processor Diagnostic and Verification Manual, part number 25595-90001.

The following paragraphs contain specific instructions for calibrating the DAC card.

8.7.1 EQUIPMENT REQUIRED

To calibrate the DAC card you need the following equipment:

1) HP 3466A digital multimeter

   OR

2) a) HP 3455A digital voltmeter

      and

   b) a .25W 100 ohm resistor

The multimeter is slightly easier to use.

8.7.2 PRELIMINARY PROCEDURE

1) Turn the power to the HP 2250 system OFF.

2) Remove the field wiring assemblies (FWAs) from the HP 25510A DAC card.

3) Remove the DAC card from its slot in the backplane and set the mode switches for each DAC channel to the desired mode of operation (unipolar voltage, bipolar voltage, or unipolar current output). The mode switches (one pair per channel) are located near the front edge of the card.

   Note that bipolar current output is not a legal option, and that such a switch setting will prevent the card from identifying itself following a power ON cycle.

4) Insert the card into its slot and turn power to the HP 2250 system ON. Make sure that the system passes self-test.

5) Allow the card to reach normal operating temperature. This warm-up period is generally 15 minutes, but it can be shorter if the card was at operating temperature before you turned off the system power. If power was off for 30 seconds or less you don't need to allow any extra warm-up time.

6) At the controller you are using (HP 1000, HP 9826, HP-85, etc.) issue the command

   ```
   ID(1,n)!
   ```

   to the HP 2250, where n is the number of function card slots in your HP 2250 system. (If you are using the MCX exerciser program, you can enter "CARDS".) This will cause the ID codes of the function cards in your system to be returned, and an ID code of 10 should be returned for the slot that contains the HP 25510A DAC card.

7) Since a voltmeter can not measure current directly, you will have to make special arrangements if you are using a voltmeter (rather than a multimeter) and if any of your channels is set for current output. This can be done easily using a .25W 100 ohm shunt resistor and Ohm's Law.

Before you make any current measurements, set your voltmeter to measure ohms and measure the value of the resistor. For this measurement, connect the resistor directly across the ohms input; that way you will avoid including the resistance of the test leads in your measurement. We will refer to the measured resistance value as "R" in the tables below.

When you measure the current output from a DAC channel, set the voltmeter to measure volts and connect the resistor directly across the volts input. Connect the test leads to the current output. The test leads and the resistor thus become part of the circuit, and the voltmeter makes a direct reading of the voltage drop across the shunt resistor. This voltage drop is equal to the product of the measured resistance and the current output; that is, E = IR. (Clever, eh?) The tables below indicate acceptable ranges for the voltages being measured.

8.7.3 VOLTAGE AND CURRENT ADJUSTMENTS

Each channel of the DAC card needs to be adjusted according to the output mode selected for that channel. A zero adjustment and a full scale adjustment are made for each channel. Do the following:

1) Make the zero adjustment:

   a) Set up the multimeter/voltmeter to measure voltage or current, as is appropriate to the output mode of the channel you are calibrating. Select a range compatible with the value in table 8-2, below. Attach the test leads of the meter to the appropriate output points.

   b) Using the exerciser program (MCX, for example) issue the appropriate command to the DAC card, as listed in table 8-2.

   c) Adjust the zero potentiometer for the channel until the meter reading is in the range specified by the table.

Table 8-2. Zero Calibration Values

Mode	MCL Command	Meter Reading
UV	VO(slot,channel)0!	-.001 V to +.001 V
BV	VO(slot,channel)-10240!	-10.242 V to -10.238 V
C	CO(slot,channel)5!	.003 mA to .007 mA or .003*R mV to .007*R mV
UV = unipolar voltage BV = bipolar voltage C = unipolar current	slot = slot number of DAC card channel = channel being calibrated	
R = resistance of shunt resistor (see item 7, above)		

2) Make the full scale adjustment:

   a) Make sure that the multimeter/voltmeter is set to a range compatible with the values in table 8-3, below.

   b) Using the exerciser program, issue the appropriate command, as listed in table 8-3.

   c) Adjust the gain potentiometer until the meter reading is in the range specified in the table.

Table 8-3. Full Scale Calibration Values

Mode	MCL Command	Meter Reading
UV	VO(slot,channel)10238!	+10.237 V to +10.238 V
BV	VO(slot,channel)10235!	+10.233 V to +10.237 V
C	CO(slot,channel)20475!	20.473 mA to 20.477 mA or 20.473*R mV to 20.477*R mV
UV = unipolar voltage BV = bipolar voltage C = unipolar current		slot = slot number of DAC card channel = channel being calibrated
R = resistance of shunt resistor (see item 7, above)		

3) Repeat steps 1 and 2 for each channel.

4) After all channels have been calibrated, use the exerciser program to issue commands to set outputs for all channels at normal levels.

5) Reconnect the field wiring and resume normal operation.

Section IX
HP 25511A 32-Point Digital Input

9.1 INTRODUCTION

This section provides information for the HP 25511A 32-Point Digital Input card. Included are specifications and a functional description. Installation information for the card is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

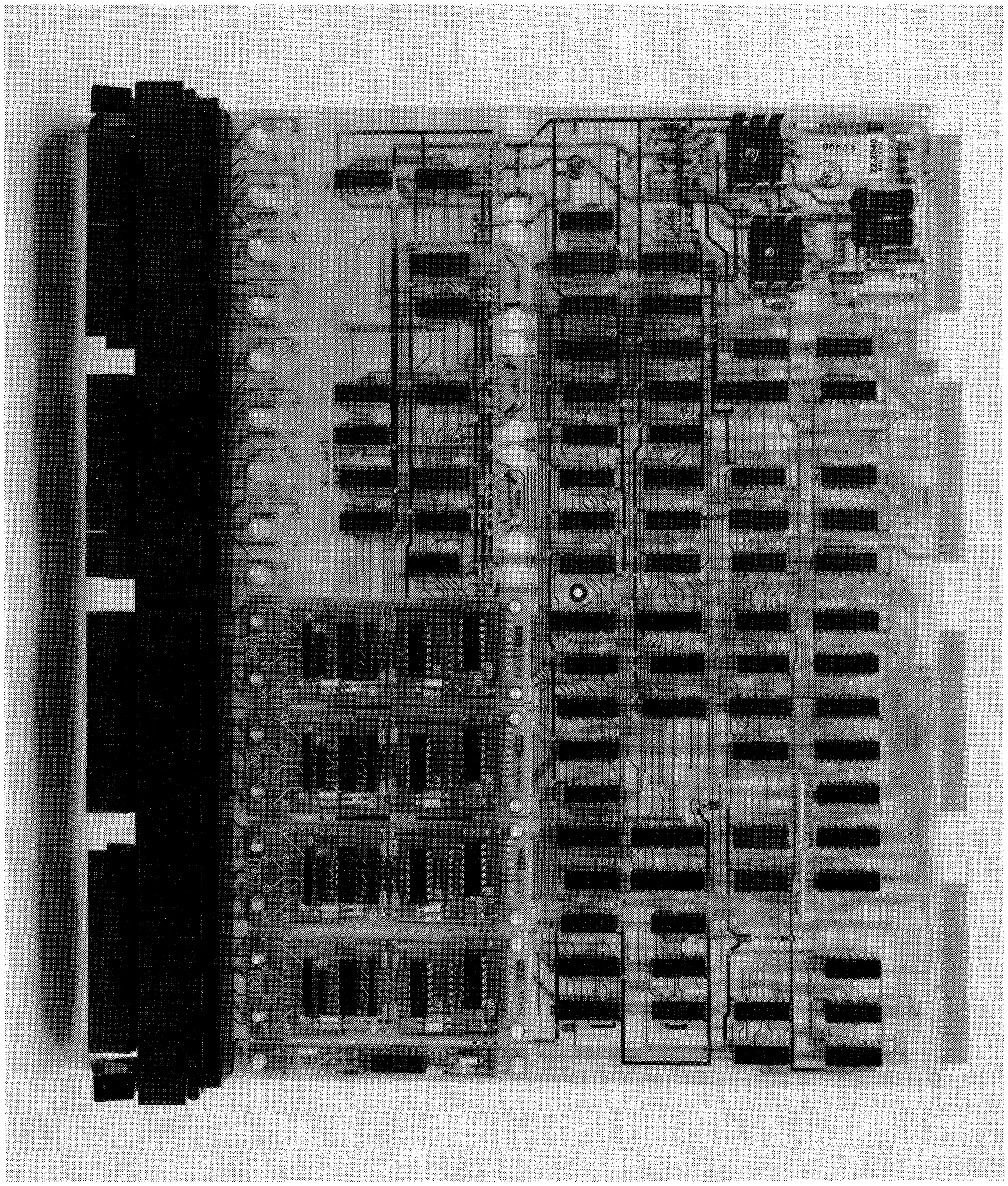
9.2 DESCRIPTION

The HP 25511A, shown in figure 9-1, provides 32 digital-input points for detecting events and reading input states. When an event occurs, an interrupt notifies the processor unit.

Events are independently defined in the controlling program for each input point. Events are defined by sense; i.e., direction of change (high to low or low to high) or either direction. The sense conditions, input states, and interrupt status are available for the processor unit to read at any time.

The 32 points are divided into two 16-point fields with a separate external strobe input for each field.

Applications for the digital input card include the monitoring of processes in industrial and laboratory systems, the monitoring of on/off conditions of all types of devices such as motors (through sensing the presence or absence of motor winding power), ac or dc relays, and the monitoring of digital instruments and digital sensors.



2250-91H

Figure 9-1. HP 25511A 32-Point Digital Input

9.3 SPECIFICATIONS

Specifications for the HP 25511A are provided in table 9-1.

Table 9-1. HP 25511A Specifications

FEATURES 32 digital input points/two 16-bit fields Interrupt detection via programmable mask and transition sense registers TTL, CMOS high-voltage inputs One external strobe per 16-bit field Isolated inputs to 230 VAC
APPLICATIONS Monitoring of digital data such as: Mechanical or solid state switches Coil/winding power sensing on relays and motors Instruments or transducers with digital outputs Any application in which information is contained in the absence or presence or an AC or DC voltage

Table 9-1. HP 25511A Specifications (Continued)

PROGRAMMING INFORMATION	
DI command:	Read a single digital input point, or sequence of points
FI command:	Read a single digital input field, or sequence
INTERRUPT command:	Enable card interrupts
RINTERRUPT command:	Read interrupt configuration
SENSE command:	Define interrupt transition sense
SOVER command:	Override transition sense for interrupts
WPOINT command:	Wait for digital input point
ELECTRICAL CHARACTERISTICS	
EXTERNAL STROBE OPERATION	
Minimum Detectable Input Pulse Width from an External Strobe Input:	1 usec
Maximum Effective External Strobe Frequency:	62.5 kHz
External Strobe to Input Data Capture Delay:	2 to 18 usec

Table 9-1. HP 25511A Specifications (Continued)

NON-EXTERNAL STROBE OPERATION

Minimum Detectable Input Pulse:

16 usec

Minimum Setup Time of Data with Respect to an Active Strobe Edge:

0 usec

Minimum Hold Time of Data with Respect to an Active Strobe Edge:

16 usec

Input Data Read Time:

42 usec (23,800 input fields per second)

Common Mode Rejection Ratio at 60 Hz:

-45 db

Common Mode Rejection Ratio at 1 kHz:

-30 db

Crosstalk Rejection Ratio:

	60 Hz	1 kHz
Measured across non-isolated SCM input:	-70 db	-55 db
Measured across isolated SCM input:	-45 db	-30 db

PHYSICAL CHARACTERISTICS

Width: 28.91 cm (11.38 in.)

Depth: 34.8 cm (13.54 in.)

Height: 3.5 cm (1.38 in.)

Weight: 680 grams (1.5 lbs)

9.4 INPUT SIGNAL CONDITIONING

Signal conditioning modules (SCMs) are used with all inputs. The SCMs are mounted on the card before the card is installed in the measurement and control unit. The SCMs add components at the input terminals for matching external signals to the card inputs. SCMs offer circuit isolation or non-isolation and a selection of signal attenuation. The SCMs available with the HP 25511A are shown in table 9-2. More information on these SCMs is provided in Section XIV.

Install the SCM, with its component side up, by aligning the guide holes in the SCM to the guide pins on the HP 25511A card, and pressing the SCM firmly into place. The physical orientation of the guide pins prevents improper installation of the SCM. The guide pins also serve as spacers to keep the SCM elevated from the surface of the card. Refer to the HP 2250 Installation and Start-Up Manual, part number 02250-90012, for further information on installing an SCM.

9.5 FUNCTIONAL DESCRIPTION

Figure 9-2 contains a functional block diagram showing the input/output buses and the major functions of the HP 25511A.

The 32 digital input points are provided in two fields identified as Field 1 and Field 2. Each field consists of 16 points and an External Strobe input. The inputs connect to external field wiring through SCMs.

In operation, the processor unit writes conditions to and reads results or contents from registers on the card. When an event is detected on one of the input points, an interrupt (if enabled) notifies the processor unit. An interrupt record is saved in a register so the processor unit can read it. In addition to monitoring the present states, the input points independently detect events by comparing the past states with the present states, and determining if any state has changed in a selected direction (low levels changed to high levels, or high levels changed to low). When an event is detected, if the point is "unmasked" its corresponding bit in its Interrupt Register will be set and an interrupt signal will be sent to the processor unit. The interrupt record of events is saved until read by the processor unit, which resets the record to zero and clears the interrupt signals.

Table 9-2. SCMs Available for Use with the HP 25511A

PRODUCT NUMBER	DESCRIPTION
HP 25531B	5 VDC Non-Isolated Source Strobe
HP 25531C	12 VDC Non-Isolated Source Strobe
HP 25531D	24 VDC Non-Isolated Source Strobe
HP 25531E	48 VDC Non-Isolated Source Strobe
HP 25531K	5 VDC Non-Isolated Sink Strobe
HP 25531L	12 VDC Non-Isolated Sink Strobe
HP 25533B	5 VDC Isolated Strobe
HP 25533C	12 VDC Isolated Strobe
HP 25533D	24 VDC Isolated Strobe
HP 25533E	48 VDC Isolated Strobe
HP 25533F	72 VDC Isolated Strobe
HP 25533G	120 VDC/72 VAC Strobe
HP 25533H	115 VAC Strobe
HP 25533J	230 VAC Strobe
HP 25535B	5 VDC Non-Isolated Source Input
HP 25535C	12 VDC Non-Isolated Source Input
HP 25535D	24 VDC Non-Isolated Source Input
HP 25535E	48 VDC Non-Isolated Source Input
HP 25535K	5 VDC Non-Isolated Sink Input
HP 25535L	12 VDC Non-Isolated Sink Input
HP 25537P	5 VDC Isolated Input
HP 25537Q	12 VDC Isolated Input
HP 25537R	24 VDC/16 VAC Isolated Input
HP 25537S	48 VDC Isolated Input
HP 25537T	72 VDC Isolated Input
HP 25537U	120 VDC/72 VAC Isolated Input
HP 25537V	115 VAC Isolated Input
HP 25537W	230 VAC Isolated Input

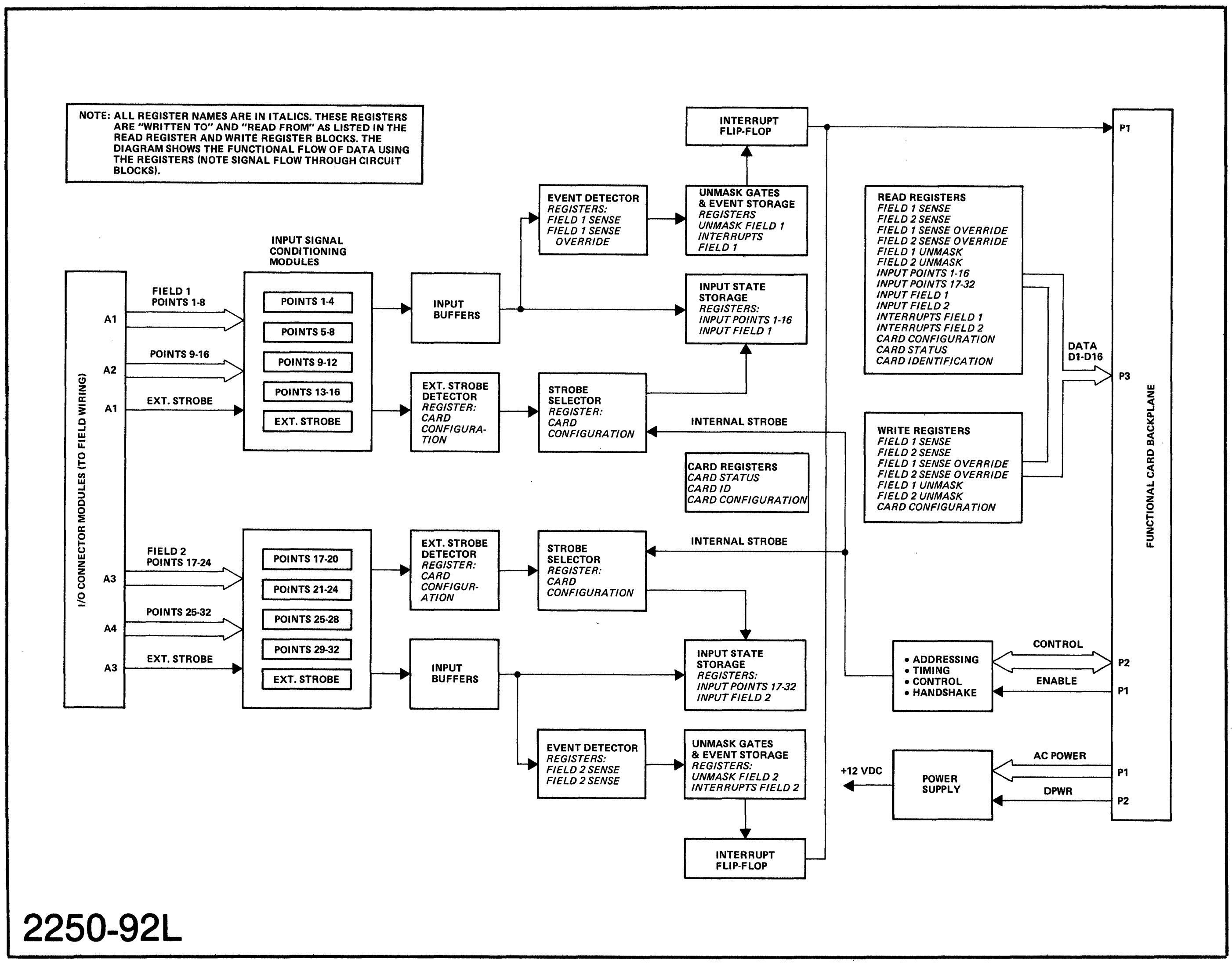


Figure 9-2. HP 25511A Functional Block Diagram

You exercise control over the card functions through writing and reading data to and from the various registers. The registers are identified by number under "Register Addressing" in Chapter 3 of this manual.

9.5.1 Input Point Data

Inputs from the field wiring enter the card through the plug-on SCMs. Each input SCM accomodates four contiguous points, and four SCMs cover one of the two 16-point fields. SCMs are selected by you to match signal levels, and to provide signal isolation, if desired. Several different types and ranges may be selected (see table 9-2).

Internal or external strobes can be employed independently on the two fields to determine when the input states will be stored in the Input Point Registers and Field Registers. Input states are stored in both Point Registers and Field Registers so they can be returned to the processor unit in either format. If only one or a few points are of interest, point reading will be faster than sorting the desired points out of a field read.

The external strobe allows you to make sure that only valid data is being input after external adjustments have been made. The state of each point at the moment a strobe occurs becomes the current or present state of that point. The external strobe is used only for reading the input states and has no effect on event detection. Event detection is performed by an independent circuit that samples the input state every 16 microseconds. Nothing is allowed to interfere with this sampling.

Whether or not the external strobe is used to specify when inputs are valid, the time at which the valid inputs are read is determined by an internal measurement strobe. This internal strobe is normally issued at the time of the read command; however, it can be delayed in order to set up several cards to be read at the same time. The cards are read when they are strobed concurrently. (This is explained under "INPUT TIMING" below.)

9.5.2 Status Readback

The card status register contains a "Strobe Wait for Data" bit (Bit 0 for field 1, and Bit 1 for field 2). When the bit is set, it means that the corresponding field is waiting for a strobe to input new data, after the previous read has completed. When it is clear, it means that the card has not yet read previous data and cannot accept new data.

9.5.3 Events

An event occurs when an input changes state either in a specified direction (Sense Register) or both directions (Sense Override Register). When the selected direction occurs on an unmasked point, the occurrence is recorded in the Interrupt Register for the point. If it is the first event in a series (the register was previously cleared) an interrupt message goes to the processor unit.

The 16-bit event detection registers contain one bit of information for each of the 16 points of two fields (one register of each type per field. The event detection registers are the following:

SENSE REGISTER: Selects one of two directions for events.

SENSE OVERRIDE REGISTER: Allows both directions for events when set.

UNMASK REGISTER: Selects which points may cause an interrupt.

INTERRUPTS REGISTER: Records which unmasked points had an event.

An input change is detected by examining each input every 16 microseconds to see if the present state differs from the past state. The event detector compares the direction of change with the desired direction of change as specified in the Sense Register and Sense Override Register. The sense bit to allow an event is a logic 1 for a low-to-high change, and it is a logic 0 for a high-to-low change.

For example, if a point has a state of 0 (low) and the sense bit for it is 1, a change from low-to-high (0 to 1) will be an event. Conversely, if a point has a state of 1 (high) and the sense bit or it is 0, a change from high-to-low (1 to 0) will be an event. Opposite changes will not result in events.

If the corresponding bit in the Sense Override Register is set to a logic 1, the effect of the sense bit will be cancelled so that all changes will qualify as events. To summarize, if either the sense override bit is set or the present state is the same as the sense bit, an event has occurred if the present state differs from the past state.

9.5.4 Unmasking Events

When an event bit for an input point is generated, it is passed as an interrupt if the corresponding bit in the Unmask Register is "true." The Unmask Registers are 16-bit registers with bits corresponding to each point of Field 1 and Field 2, respectively. If the bit is (1), the point is "unmasked" and the bit is passed through and recorded for that point in its Interrupt Register. If the bit is (0), the point is "masked" and the event bit is not passed through.

9.5.5 Interrupt Recording

An event bit is stored in an Interrupt Register if it is the first one after a register reset to zero. If a bit for that point is already stored, nothing is changed by another event bit. The first event for any point after a reset to zero will set the Interrupt Flip-Flop which notifies the processor unit, through the Function Card Backplane, that an event has occurred. The card's Interrupt Enable bit must be set in order for the interrupt to propagate through to the processor unit.

Both the Interrupt Register and Interrupt Flip-Flop are reset, or cleared, when the Interrupt Register is read. The clearing is done in such a way that any event occurring during the read and clear will not be lost. It will either be included in the simultaneously occurring read, or it will be stored in the register for the next read.

9.5.5.1 Event Detection

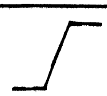
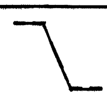
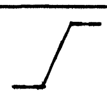
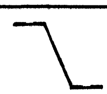
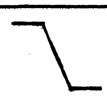
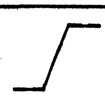
An event will be detected according to the summary shown in table 9-3, which shows changes in input signal level versus corresponding register bits, and whether an event resulted.

9.5.6 Timing

9.5.6.1 Register Timing

The registers are timed to operate serially at 1 microsecond per bit so that reads or writes to 16 points requires 16 microseconds. Backplane signals are asynchronous to card time; therefore, reading and writing is made a constant 33 microsecond period to allow sychronization of the card. Added to this time there is a backplane overhead time of 8 microseconds.

Table 9-3. Event Summary

INPUT SIGNAL	SENSE OVERRIDE	SENSE	EVENT
	1	0 or 1	YES
	1	0 or 1	YES
	0	1	YES
	0	1	NO
	0	0	YES
	0	0	NO

9.5.6.2 Input Timing

The Card Configuration Register is used to select either the non-external strobe mode or the external strobe mode and the strobe polarity. Bit 0 and Bit 1 select the strobe mode for Field 1 and Field 2, respectively. A logic 0 selects the non-external strobe mode, and logic 1 selects the external strobe mode. The external strobe polarity is selected by Bit 8 and Bit 9 for Field 1 and Field 2, respectively. When set to logic 1 the input states latch on the rising edge of the strobe, and when set to logic 0 the inputs latch on the falling edge of the strobe.

There are two program variations for strobes to input data, store it in a register, and read it. This is to provide commands to "read with measurement strobe" or "read without measurement strobe" for immediate or delayed data reading, respectively. A measurement strobe is the internal strobe signal.

Figure 9-3 illustrates the non-external strobe mode where the internal measurement strobe stores the input data. As in cycle 1, every time there is a measurement strobe and a read command together (read with measurement strobe), the present data is returned as valid data. As in cycle 2, when the measurement strobe is omitted (read without measurement strobe) the previous data (cycle 1) is returned since no new data was stored. The "read without measurement strobe" will cause data to be input on the next measurement strobe but from then on the measurement strobe is disabled until the stored data is read, as shown in cycles 3 through 5. The measurement strobe is reenabled for cycle 6 since the data was read in cycle 5. Optionally, cycle 6 may have a "read with measurement" strobe to return data immediately " or the read command may be omitted for delayed reading as shown.

When a field or point has been configured to the external strobe mode, the operation is similar to the non-external strobe mode, described above, except that the external strobe substitutes for the measurement strobe to input data. External strobe operation is illustrated in figure 9-4.

NO EXT. STROBE MODE (CONFIG. REG.: FLD. 1 BIT 0=0 OR FLD. 2 BIT 1=0						
OCCURRENCE (FIELD 1 OR FIELD 2)	IMMEDIATE READ	NO STROBE	DELAYED READ			REENABLED STROBE
	CYCLE 1	CYCLE 2	CYCLE 3	CYCLE 4	CYCLE 5	CYCLE 6
Input Data	1	2	3	4	5	6
Meas. Strobe	▲	NONE	▲	▲	NONE	▲
Input Read	▲	▲	NONE	NONE	▲	NONE
Stored Data	1	1	3	3	3	6
Data Read	1	1	NONE	NONE	3	NONE

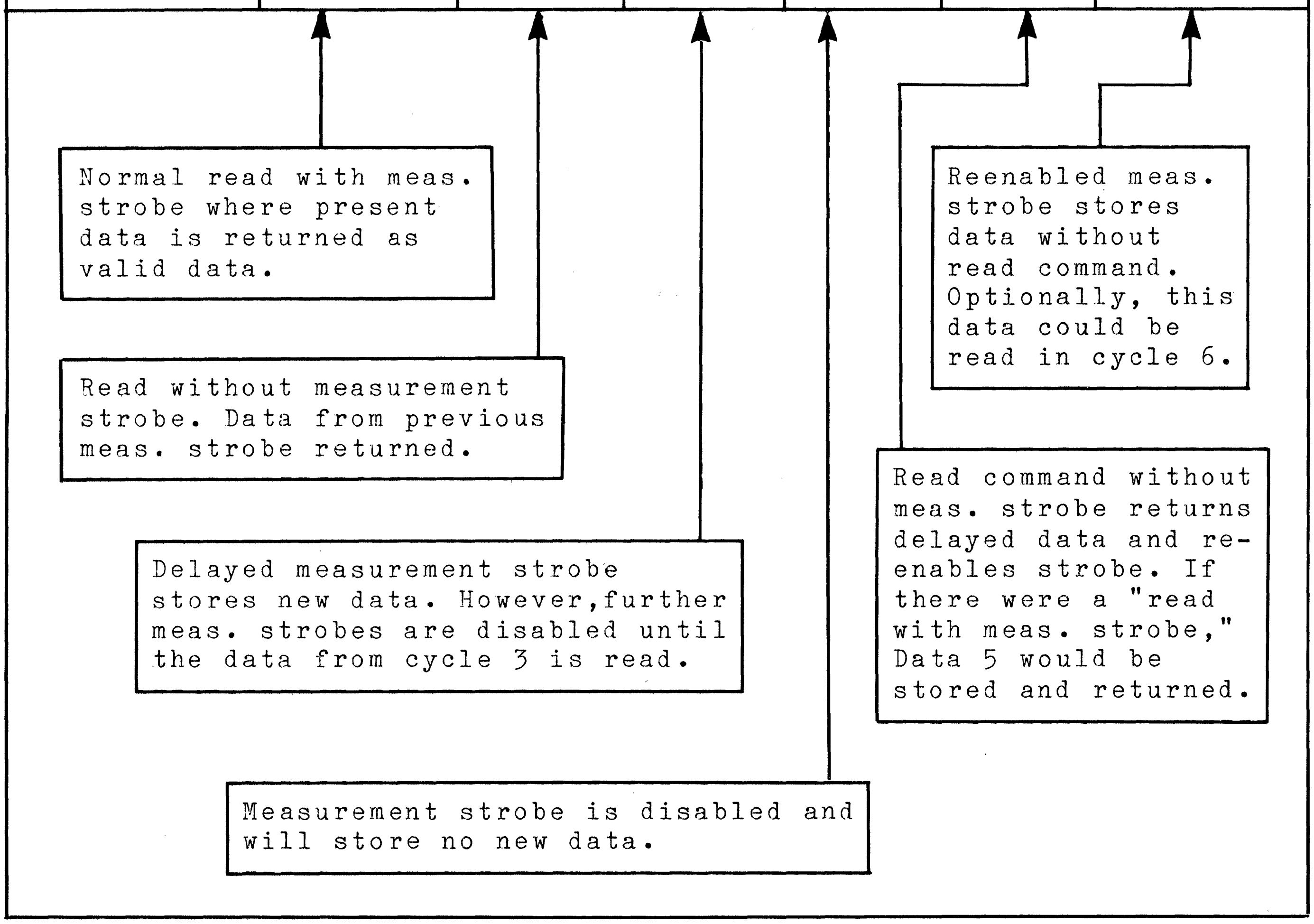


Figure 9-3. Non-External Strobe Mode Operation

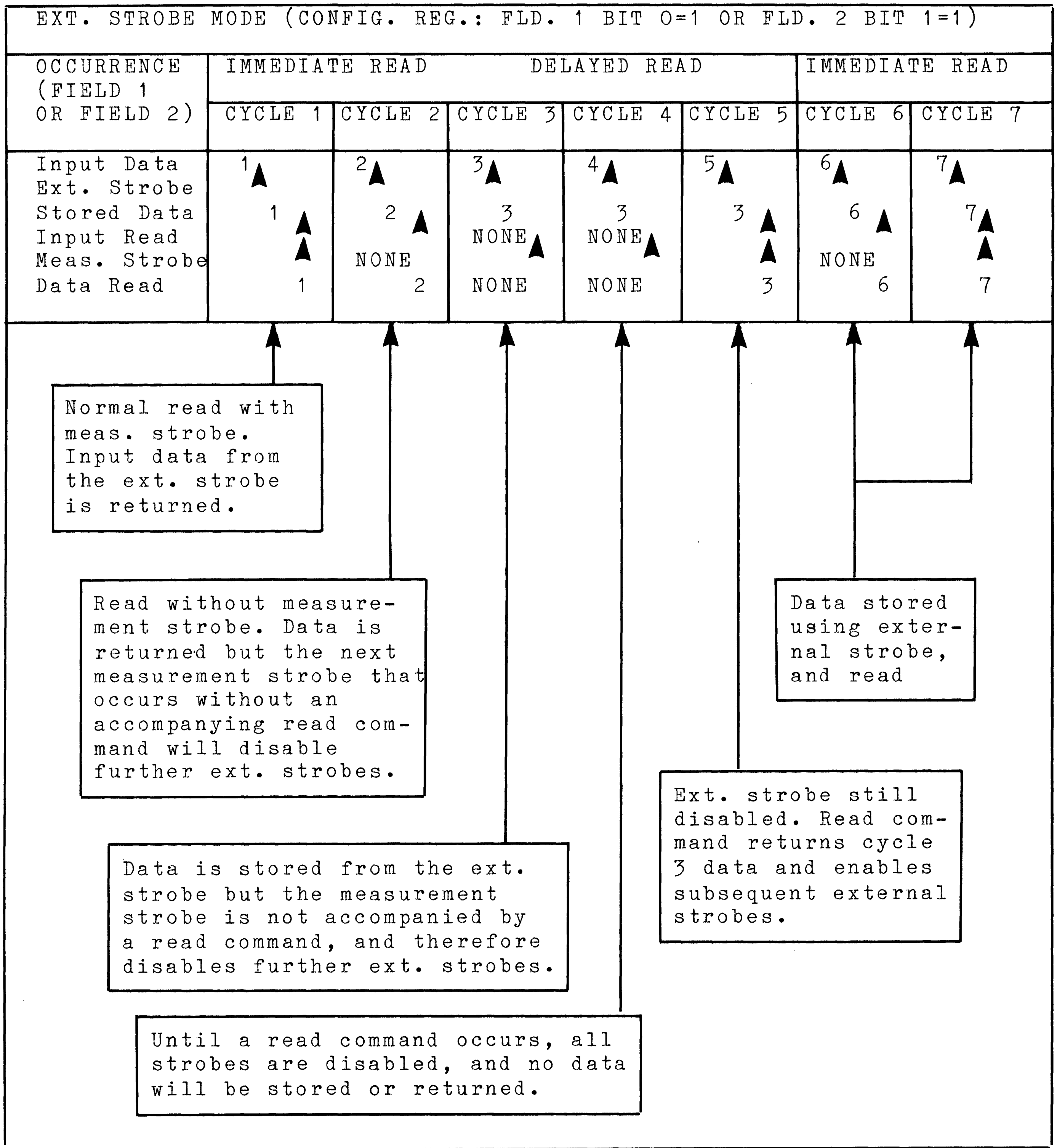


Figure 9-4. External Strobe Mode Operation

In cycle 1 there is an external strobe and data is input. This data is read using the "read with measurement strobe" command. In cycle 2 data is input with the external strobe but this time a "read without measurement strobe" command is used. Therefore, the next external strobe inputs data as shown in cycle 3, and since there is no read command the external strobe is ignored in cycles 4 and 5. A read command in cycle 5 returns the stored data of cycle 3 and reenables the external strobe for cycle 6.

9.6 REGISTER ASSIGNMENTS

Register assignments for the digital input card are shown in table 9-4.

The raw data available from the register addresses on pages 1 and 2 of a digital input card are the current values of the input points. These values are either 0 or 1 for each point; the higher 15 bits of the data word returned will always be 0.

The only register addresses on pages 9-12 that have any significance on the digital input cards are as shown in the diagram. Reading from these addresses returns the current input values for each input field. Field 1 is defined as points 1 through 16, field 2 is points 17 through 32, the lowest numbered point being in the least significant bit of the field.

Page 13 holds the interrupt mask and sense register addresses.

The card configuration register of the digital input card is used to configure for external strobe.

Bit	Meaning
0	Enable external strobe for Field 1
1	Enable external strobe for Field 2
2-7	Undefined
8	If bit 0 is set, bit 8 sets the type of transition for the strobe: if bit 8 is set, use the rising edge; if bit 8 is clear, use the falling edge.
9	If bit 1 is set, bit 9 sets the type of transition for the strobe: if bit 9 is set, use the rising edge; if bit 9 is clear, use the falling edge.
10-31	Undefined

If bit 0 of the status register is true, it indicates that field 1 is waiting for the external strobe or an internal trigger. Bit 1 has the same meaning for field 2. The remainder of the bits of the status register have no meaning.

TABLE 9-4. DIGITAL INPUT REGISTER ASSIGNMENTS

	word 1 word 2	word 1 word 2	word 1 word 2	word 1 word 2
	PAGE 1	PAGE 2	PAGE 3	PAGE 4
1	POINT 1	POINT 17		
2	POINT 2	POINT 18		
3	POINT 3	POINT 19		
4	POINT 4	POINT 20		
5	POINT 5	POINT 21		
6	POINT 6	POINT 22		
7	POINT 7	POINT 23		
8	POINT 8	POINT 24		
9	POINT 9	POINT 25		
10	POINT 10	POINT 26		
11	POINT 11	POINT 27		
12	POINT 12	POINT 28		
13	POINT 13	POINT 29		
14	POINT 14	POINT 30		
15	POINT 15	POINT 31		
16	POINT 16	POINT 32		

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1				
2				
3				
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7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

TABLE 9-4. DIGITAL INPUT REGISTER ASSIGNMENTS, CONTINUED

	PAGE 9	PAGE 10	PAGE 11	PAGE 12
	word 1 word 2	word 1 word 2	word 1 word 2	word 1 word 2
1			FIELD 1	
2			FIELD 2	
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1		SENSE 1	UNMASK 1	INTERRUPTS 1
2		SENSE 2	UNMASK 2	INTERRUPTS 2
3		OVERRIDE 1		
4		OVERRIDE 2		
5				
6				
7				
8				
9				CARD CONFIG
10				0
11				CARD STATUS
12				0
13				CARD ID REG
14				0
15				0
16				BIF

9.7 PIN ASSIGNMENTS AND CABLING

Table 9-5 shows the signals that are routed to the card connector pins on the edge of the card. The connector numbering scheme is shown in figure 3-11, at the end of Section III of this manual.

Table 9-5. HP 25511A I/O Connector Module Pin Assignments

CONNECTOR	PINS	CONNECTION	CONNECTOR	PINS	CONNECTION
A1J1	1,2	R=147 ohms	A3J1	1,2	R=147 ohms
A1J1	3	Fld. 1 Strobe	A3J1	3	Fld. 2 Strobe
A1J1	4	Strobe Gnd.	A3J1	4	Strobe Gnd.
A1J2	1	Pt. 1 +	A3J2	1	Pt. 17 +
A1J2	2	Pt. 1 -	A3J2	2	Pt. 17 -
A1J2	3	Pt. 2 +	A3J2	3	Pt. 18 +
A1J2	4	Pt. 2 -	A3J2	4	Pt. 18 -
A1J5	1	Pt. 3 +	A3J5	1	Pt. 19 +
A1J5	2	Pt. 3 -	A3J5	2	Pt. 19 -
A1J5	3	Pt. 4 +	A3J5	3	Pt. 20 +
A1J5	4	Pt. 4 -	A3J5	4	Pt. 20 -
A1J6	1	Pt. 5 +	A3J6	1	Pt. 21 +
A1J6	2	Pt. 5 -	A3J6	2	Pt. 21 -
A1J6	3	Pt. 6 +	A3J6	3	Pt. 22 +
A1J6	4	Pt. 6 -	A3J6	4	Pt. 22 -
A1J9	1	Pt. 7 +	A3J9	1	Pt. 23 +
A1J9	2	Pt. 7 -	A3J9	2	Pt. 23 -
A1J9	3	Pt. 8 +	A3J9	3	Pt. 24 +
A1J9	4	Pt. 8 -	A3J9	4	Pt. 24 -
A2J1	1,2	R=147 ohms	A4J1	1,2	R=147 ohms
A2J1	3,4	NOT USED	A4J1	3,4	NOT USED
A2J2	1	Pt. 9 +	A4J2	1	Pt. 25 +
A2J2	2	Pt. 9 -	A4J2	2	Pt. 25 -
A2J2	3	Pt. 10 +	A4J2	3	Pt. 26 +
A2J2	4	Pt. 10 -	A4J2	4	Pt. 26 -
A2J5	1	Pt. 11 +	A4J5	1	Pt. 27 +
A2J5	2	Pt. 11 -	A4J5	2	Pt. 27 -
A2J5	3	Pt. 12 +	A4J5	3	Pt. 28 +
A2J5	4	Pt. 12 -	A4J5	4	Pt. 28 -
A2J6	1	Pt. 13 +	A4J6	1	Pt. 29 +
A2J6	2	Pt. 13 -	A4J6	2	Pt. 29 -
A2J6	3	Pt. 14 +	A4J6	3	Pt. 30 +
A2J6	4	Pt. 14 -	A4J6	4	Pt. 30 -
A2J9	1	Pt. 15 +	A4J9	1	Pt. 31 +
A2J9	2	Pt. 15 -	A4J9	2	Pt. 31 -
A2J9	3	Pt. 16 +	A4J9	3	Pt. 32 +
A2J9	4	Pt. 16 -	A4J9	4	Pt. 32 -

The connection between the digital input card and the field wiring is made with one of two cables:

HP 25550A (digital card cable with screw terminations)

HP 25550B (digital card cable, unterminated)

Section X
HP 25513A 32-Point Digital Output

10.1 INTRODUCTION

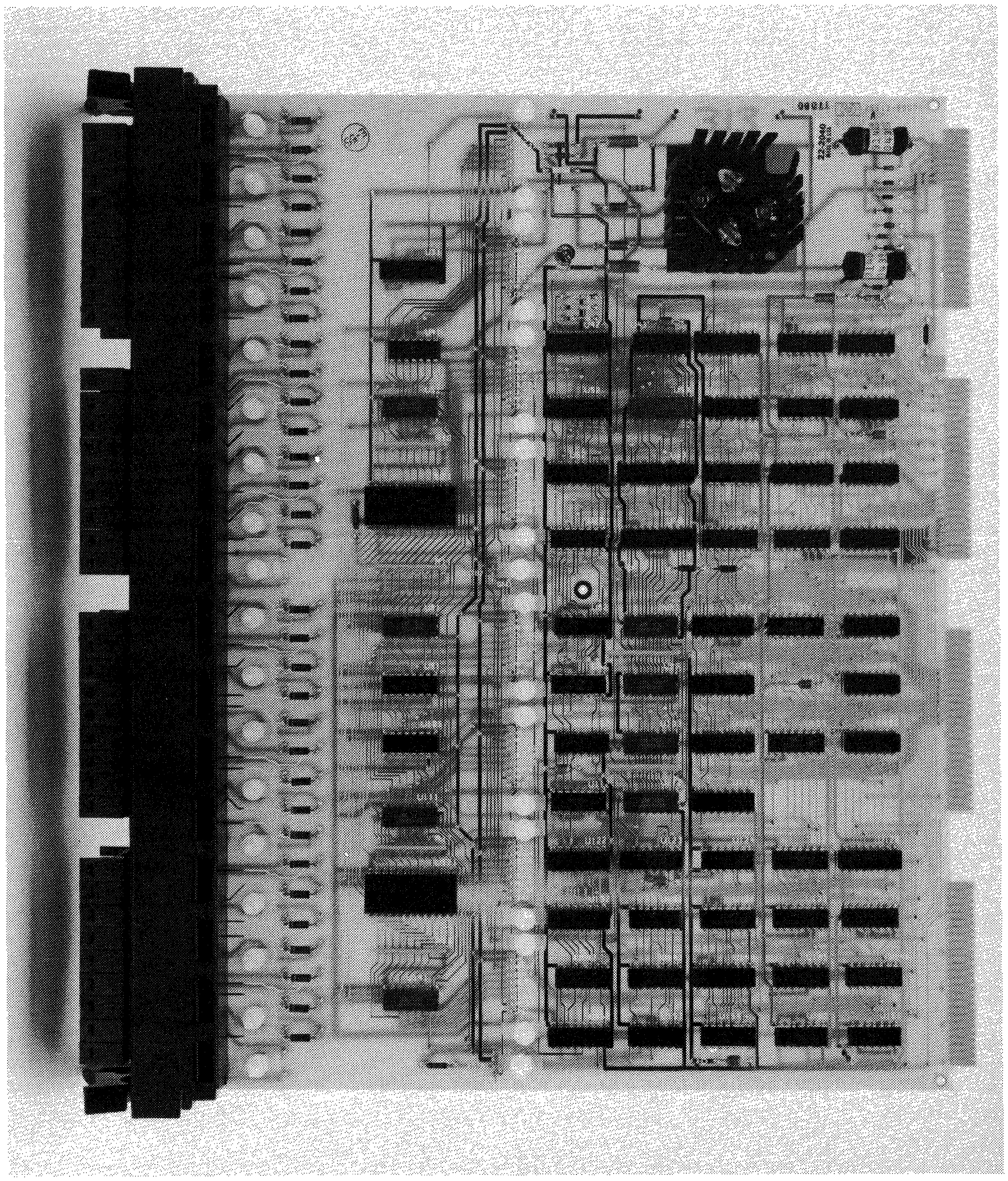
This section provides information for the HP 25513A 32-Point Digital Output card. Included are specifications and a functional description. Installation information for the card is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

10.2 DESCRIPTION

The HP 25513A, shown in figure 10-1, provides 32 points which switch states independently. The high and low (open and closed) switched states are matched to the application requirements by signal conditioning modules (SCMs). The 32 points are divided into two fields of 16 points each. Each field includes an external strobe input so that output state changes can be synchronized with the application.

10.3 SPECIFICATIONS

Specifications for the HP 25513A are provided in table 10-1.



2250-95H

Figure 10-1. HP 25513A 32-Point Digital Output

Table 10-1. HP 25513A Specifications

FEATURES

32 digital output points

Channels programmed independently or as two 16-bit fields

External strobe can synchronize output changes to an external event (one per 16-bit field)

AC/DC switching to 60 V peak (42 VAC), 400 mA peak

AC zero voltage switching to 120 VAC, 1.5 A peak (16 channels, maximum)

APPLICATIONS

Provides solid state switching of AC and DC loads such as lamps, relays, solenoids, TTL, CMOS, displays, and small AC/DC motors.

PROGRAMMING INFORMATION

DO command:	Write sequential digital outputs
RDO command:	Read sequential digital outputs
FO command:	Write sequential digital output fields (16 bits)
RFO command:	Read sequential digital output fields (16 bits)

ELECTRICAL CHARACTERISTICS

LOADS:

Resistive or inductive

OUTPUT DATA UPDATE TIME:

24 usec

Table 10-2. HP 25513A Specifications (Continued)

MAXIMUM EFFECTIVE EXTERNAL STROBE FREQUENCY:		
41.7 kHz		
MAXIMUM EXTERNAL STROBE TO OUTPUT DELAY:		
2 usec		
CROSSTALK REJECTION RATIO (100 K ohm load, channel-to-channel)		
	60 Hz:	-62 db
	1 kHz:	-45 db
	5 kHz:	-30 db
	10 kHz:	-26 db
PHYSICAL CHARACTERISTICS		
	Width:	28.91 cm (11.38 in.)
	Depth:	34.8 cm (13.54 in.)
	Height:	3.5 cm (1.38 in.)
	Weight:	680 grams (1.5 lbs)

10.4 SIGNAL CONDITIONING

The HP 25513A can drive a variety of logic circuits through the use of signal conditioning modules (SCMs). SCMs are available for such application requirements as isolated or non-isolated outputs, DC, AC, and AC/DC switches. SCMs available with the HP 25513A are shown in table 10-2. More information on these SCMs is provided in Section XIV.

Table 10-2. SCMs Available for Use with the HP 25513A

PRODUCT NUMBER	DESCRIPTION
HP 25531B	5 VDC Non-Isolated Source Strobe
HP 25531C	12 VDC Non-Isolated Source Strobe
HP 25531D	24 VDC Non-Isolated Source Strobe
HP 25531E	48 VDC Non-Isolated Source Strobe
HP 25531K	5 VDC Non-Isolated Sink Strobe
HP 25531L	12 VDC Non-Isolated Sink Strobe
HP 25533B	5 VDC Isolated Strobe
HP 25533C	12 VDC Isolated Strobe
HP 25533D	24 VDC Isolated Strobe
HP 25533E	48 VDC Isolated Strobe
HP 25533F	72 VDC Isolated Strobe
HP 25533G	120 VDC/72 VAC Strobe
HP 25533H	115 VAC Strobe
HP 25533J	230 VAC Strobe
HP 25539A	Relay Arc Suppression Breadboard
HP 25539E	30 VDC Load Relay Arc Suppression
HP 25539G	24 VAC Load Relay Arc Suppression
HP 25539H	115 VAC Load Relay Arc Suppression
HP 25539J	230 VAC Load Relay Arc Suppression
HP 25543N	60 VDC/42 VAC Isolated Output
HP 25544A	Open Drain, Non-Isolated Output
HP 25544B	5 VDC Non-Isolated Output
HP 25544C	12 VDC Non-Isolated Output
HP 25545P	115 VAC Isolated Output

The types of SCMs used determine the number of points per I/O Connector Module, and the number of points available for field wiring. The SCMs for DC outputs contain four points, and SCMs for AC outputs contain two points (AC SCMs divide the number of available points by two). Both AC and DC SCMs can be installed on the same card.

SCMs are mounted on the card before the card is installed in the measurement and control unit. Install the SCM, with its component side up, by aligning the guide holes in the SCM to the guide pins on the HP 25513A card, and pressing the SCM firmly into place. The physical orientation of the guide pins prevents improper installation of the SCM. The guide pins also serve as spacers to keep the SCM elevated from the surface of the card. Refer to the HP 2250 Installation and Start-Up Manual, part number 02250-90012, for further information on installing an SCM.

There are two terminals per output point which differ in location on the I/O Connector Modules according to whether it is an AC or DC point. The terminals for DC points may be used for reference in locating terminals for AC points.

The DC SCMs have plus and minus connections (the minus connection is ground in non-isolated SCMs), and AC SCMs have two non-polarized terminals. The AC terminal pairs correspond with the odd-numbered plus (+) DC terminals and the even-numbered minus (-) DC terminals. For example, an AC SCM may connect to the terminals corresponding to DC point 1 (+) to DC point 2 (-), and another from DC point 3 (+) to DC point 4 (-). AC and DC SCMs can be mixed on the same card.

AC SCMs output data is addressed to the odd-numbered (+) DC point register locations. If an even-numbered DC point register location is addressed which is connected to an AC SCM, there will be no output response. This should be kept in mind when mixing SCMs on the same card in order to facilitate the programming of sequential points. That is, position all the DC SCMs together and the AC SCMs together, unless there is some reason not to, such as combining DC and AC outputs with the same external strobe input.

Be sure to identify the terminals of any two-point AC SCMs to prevent errors in field wiring and programming.

10.5 FUNCTIONAL DESCRIPTION

Figure 10-2 contains a functional block diagram showing the input/output buses and the major functions of the HP 25513A.

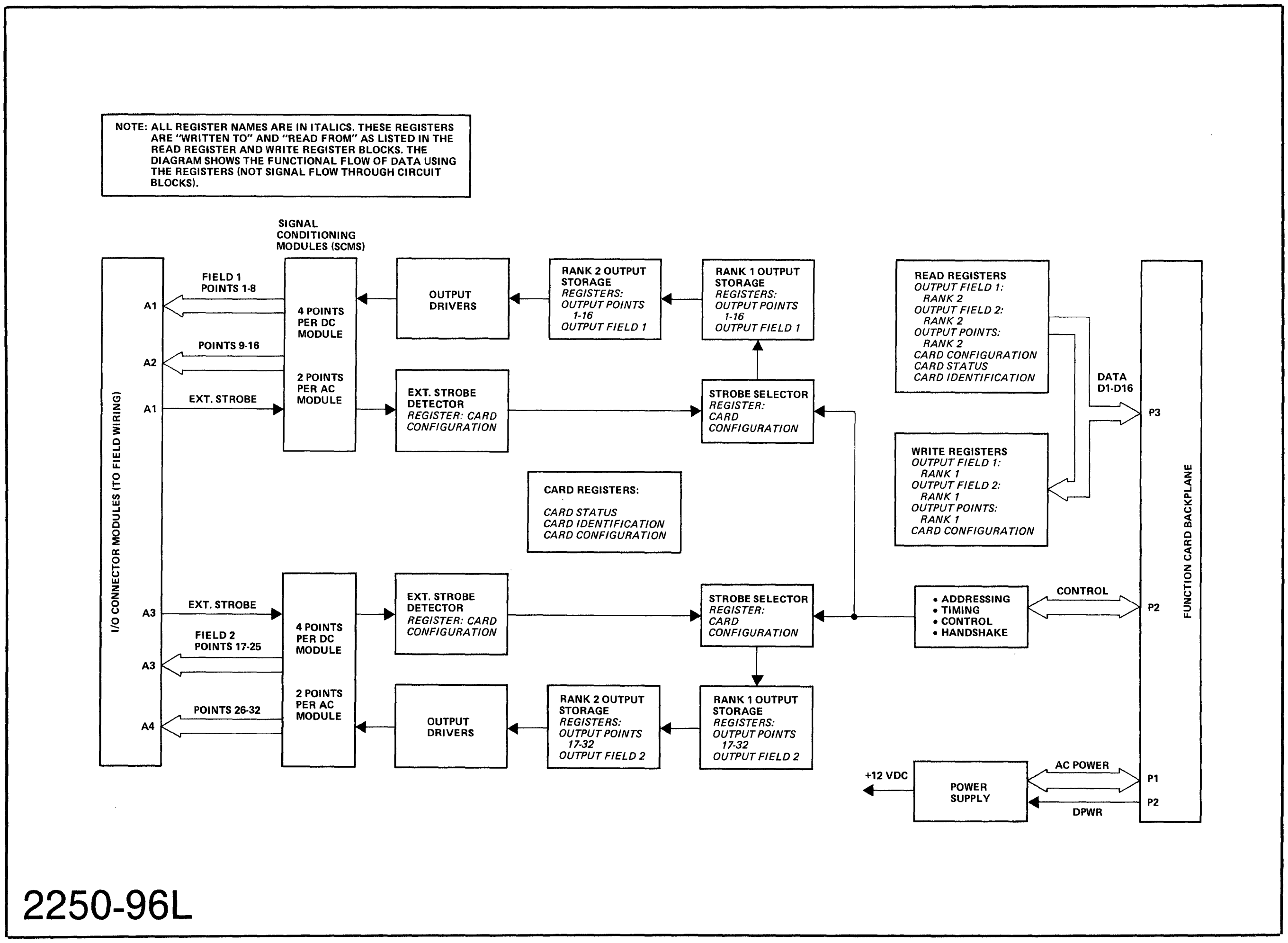


Figure 10-2. HP 25513A Functional Block Diagram

The 32 digital output points are provided in two fields identified as Field 1 and Field 2. Individual points of the two fields can be programmed separately. Each field consists of 16 points with an External Strobe input. The outputs connect to the external field wiring through the SCMs.

The programmed states of the output field points (high or low levels) are stored in rank 1 of the Output Field Register and move to rank 2 when internally or externally strobed. Rank 2 drives the output lines connecting to the field wiring.

You exercise control of the card functions through writing and reading data to and from the various registers. The registers are identified and described under "Register Addressing" in Section III.

10.5.1 Output Point Data

You may write output point data either one point at a time to the appropriate output point register or 16 points concurrently as a field to the output field register. A logic 1 closes the output switch, and a logic 0 opens (clears) clears it.

Initially at "power on" or processor unit reset, all outputs will be open (clear); i.e., the data word in the output point registers will be all 0s.

For the 16-bit output field register, the 1 or 0 value of each bit is the data for the corresponding output point. The least significant bit corresponds with the lowest numbered point, the next least significant bit corresponds with the next to the lowest numbered point, etc.

The output field (output point data) is moved through two stages (or ranks) of the Output Field Register to reach the output lines. This allows the time that the data reaches the output lines to be precisely controlled.

When the data is written, it is stored in the first rank as soon as the output command is executed but it is not necessarily transferred immediately to the second rank which drives the output switches. A measurement strobe or measurement strobe plus external strobe, depending on internal or external strobe programming, is required. The measurement strobe can be requested with the write command (write with measurement strobe) or it can be delayed (write without measurement strobe). Internal and external strobe timing is described below under "STATE TIMING."

Output data is written to the card as a single word. An output register read returns the contents of the second rank (the output states).

10.5.2 Status Readback

Output data is written to the card as a single word. An output register read returns the contents of the second rank (the output states). The read can be by the field or one point at a time.

The Card Status Register contains "Strobe Wait for Data" bits. Bit 0 is for field 1 and Bit 1 is for field 2. When the bit is set, new data has entered the Output Field Register Rank 1. When the bit is clear, the new data has been strobed into rank 2.

10.5.3 Timing

10.5.3.1 Register Timing

The registers are timed to operate serially at 1 microsecond per bit so that reads or writes to 16 points requires 16 microseconds. A backplane write and execution takes 16 shift cycles and one store cycle for a total time of 17 microseconds plus the backplane overhead time of 8 microseconds (25 microseconds total).

10.5.3.2 State Timing

The internal or external strobe is selected on the card according to the conditions specified in the Card Configuration Register. The programmed condition for Field 1 is in the register's LSB (Bit 0), and for Field 2 it is in the next LSB (Bit 1). The bits equal logic 0 for internal strobe and logic 1 for external strobe.

The latching polarity of the external strobe is selected by the condition in Bit 8 for Field 1 and Bit 9 for Field 2 of the Card Configuration Register. Assuming the external strobe mode is programmed, then a Logic 1 in bit 8 or 9 of the card configuration register will cause the corresponding output field to be strobed to rank 2 on the rising edge of the strobe. Similarly, a Logic 0 in these bits strobes on the falling edge.

When the external strobe mode is disabled, a "write with measurement strobe" stores new data in rank 1 and transfers it to rank 2 immediately. A "write without measurement strobe" stores new data in rank 1 but the transfer of data from rank 1 to rank 2 is delayed.

Writing without a measurement strobe allows several cards to be set up with data, or several single channel changes to be madé in several writes, and then the output on all the cards can be changed simultaneously.

With external strobe enabled, when a point or or field is set up with a "write with measurement strobe," the external strobe immediately following the internal measurement strobe will transfer the rank 1 data to rank 2 and the output. However, if the card is set up with the external strobe enabled and a "write without measurement strobe" is used to input new data into rank 1, the old state remains constant in rank 2. An internal strobe must activate the external strobe, then the next external strobe will move new data from rank 1 to rank 2. That is, external strobes must be preceded by an internal strobe to be effective.

The examples shown in figure 10-3 show fields of data which are output with the card configured for both the internal strobe mode and external strobe mode with several conditions:

> The Configuration Register is written to, setting Bit 0=0 for Field 1 and Bit 1=0 for Field 2, and the external strobe for the field is disabled. Cycle 1 starts with a "write with measurement strobe" command and the transfer of data to the output is immediate.
>
> Cycle 2 is a "write without measurement strobe" command, and the state is stored in rank 1, waiting for a strobe. Data 2 is output following the internal strobe which occurs in Cycle 3, since the data in rank 1 was not changed.
>
> The Configuration Register is written to, setting Bit 0=1 and Bit 1=1 for the selected field or fields, which enables the external strobe mode.
>
> Cycle 4 begins with a "write with measurement strobe" and Data 4 is stored in rank 1. The stored data moves to Rank 2 and output on the following external strobe.
>
> Cycle 5 begins with a "write without measurement strobe" and Data 5 is written into rank 1. The following external strobe has no effect on storing Data 5 in rank 2 since the internal strobe was omitted. In Cycle 6 the internal strobe is supplied, and the following external strobe moves Data 5 into rank 2 and the output.

OCCURRENCE	WRT *	EXTERNAL STROBE OFF			WRT *	EXTERNAL STROBE ON		
		CYCLE 1	CYCLE 2	CYCLE 3		CYCLE 4	CYCLE 5	CYCLE 6
Write Config.	0				1			
Write Data		1	2	NONE		4	5	NONE
Rank 1 Data		1	2	2		4	5	5
Meas. Strobe		^	NONE	^		^	NONE	^
Ext. Strobe						^	^	^
Rank 2 Data		1	1	2		4	4	5
Output		1	1	2		4	4	5

*Write to Configuration Register Bit 0.

Figure 10-3. Outputs with Various Strobe Conditions

10.6 REGISTER ASSIGNMENTS

Register assignments for the digital output card are shown in table 10-3.

The digital output card reads no external inputs.

The register addresses on pages 5 and 6 are the point output register addresses. Writing to these addresses will cause the corresponding output point to output the value of the lowest bit in the register (bit 0). Reading from these addresses will give the current output value of that point, which will be either 0 or 1.

The only addresses used on pages 9-12 are as shown. These addresses are for field outputs; writing to them will cause the written value to be output on points 1 through 16 for field 1, points 17 through 32 for field 2; reading from them will give the current output value for the corresponding field. The least significant bit corresponds to the lowest numbered point in the field.

The card configuration is used to configure the card for external strobe. The meaning of the bits is as follows.

Bit	Meaning
0	Enable strobe for Field 1
1	Enable strobe for Field 2
2-7	Undefined
8	If bit 0 is set, this bit controls which transition of the strobe to use. If bit 8 is set, the rising edge of the strobe is used. If bit 8 is clear, the falling edge of the strobe is used.
9	Bit 9 controls the valid transition of the strobe for field 2 just like bit 8 does for field 1.
10-31	Undefined

There are three meaningful bits in the card status register. If bit 0 is set, field 1 is waiting for an external strobe signal or an internal trigger. If bit 1 is set, field 2 is waiting for an external strobe or an internal trigger. If bit 15 is set, the card is busy.

TABLE 10-3. DIGITAL OUTPUT REGISTER ASSIGNMENTS

word 1 word 2 word 1 word 2 word 1 word 2 word 1 word 2

	PAGE 1	PAGE 2	PAGE 3	PAGE 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1	POINT 1	POINT 17		
2	POINT 2	POINT 18		
3	POINT 3	POINT 19		
4	POINT 4	POINT 20		
5	POINT 5	POINT 21		
6	POINT 6	POINT 22		
7	POINT 7	POINT 23		
8	POINT 8	POINT 24		
9	POINT 9	POINT 25		
10	POINT 10	POINT 26		
11	POINT 11	POINT 27		
12	POINT 12	POINT 28		
13	POINT 13	POINT 29		
14	POINT 14	POINT 30		
15	POINT 15	POINT 31		
16	POINT 16	POINT 32		

TABLE 10-3. DIGITAL OUTPUT REGISTER ASSIGNMENTS, CONTINUED

word 1 word 2 word 1 word 2 word 1 word 2 word 1 word 2

	PAGE 9	PAGE 10	PAGE 11	PAGE 12
1				FIELD 1
2				FIELD 2
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1				
2				
3				
4				
5				
6				
7				
8				
9				CARD CONFIG
10				0
11				CARD STATUS
12				0
13				CARD ID REG
14				0
15				0
16				BIF

10.7 PIN ASSIGNMENTS AND CABLING

Table 10-4 shows the signals that are routed to the card connector pins on the edge of the card. The connector numbering scheme is shown in figure 3-11, at the end of Section III of this manual.

Table 10-4. HP 25513A I/O Connector Module Pin Assignments

CONNECTOR	PINS	CONNECTION	CONNECTOR	PINS	CONNECTION
A1J1	1,2	178 ohm res	A3J1	1,2	178 ohm res
A1J1	3	Fld.1 Strobe	A3J1	3	Fld.2 Strobe
A1J1	4	Strobe Gnd.	A3J1	4	Strobe Gnd.
A1J2	1	Pt. 1 +	A3J2	1	Pt. 17 +
A1J2	2	Pt. 1 -	A3J2	2	Pt. 17 -
A1J2	3	Pt. 2 +	A3J2	3	Pt. 18 +
A1J2	4	Pt. 2 -	A3J2	4	Pt. 18 -
A1J5	1	Pt. 3 +	A3J5	1	Pt. 19 +
A1J5	2	Pt. 3 -	A3J5	2	Pt. 19 -
A1J5	3	Pt. 4 +	A3J5	3	Pt. 20 +
A1J5	4	Pt. 4 -	A3J5	4	Pt. 20 -
A1J6	1	Pt. 5 +	A3J6	1	Pt. 21 +
A1J6	2	Pt. 5 -	A3J6	2	Pt. 21 -
A1J6	3	Pt. 6 +	A3J6	3	Pt. 22 +
A1J6	4	Pt. 6 -	A3J6	4	Pt. 22 -
A1J9	1	Pt. 7 +	A3J9	1	Pt. 23 +
A1J9	2	Pt. 7 -	A3J9	2	Pt. 23 -
A1J9	3	Pt. 8 +	A3J9	3	Pt. 24 +
A1J9	4	Pt. 8 -	A3J9	4	Pt. 24 -
A2J1	1,2	R= 178 ohms	A3J1	1,2	R= 178 ohms
A2J1	3,4	NOT USED	A4J1	3,4	NOT USED
A2J2	1	Pt. 9 +	A4J2	1	Pt. 25 +
A2J2	2	Pt. 9 -	A4J2	2	Pt. 25 -
A2J2	3	Pt. 10 +	A4J2	3	Pt. 26 +
A2J2	4	Pt. 10 -	A4J2	4	Pt. 26 -
A2J5	1	Pt. 11 +	A4J5	1	Pt. 27 +
A2J5	2	Pt. 11 -	A4J5	2	Pt. 27 -
A2J5	3	Pt. 12 +	A4J5	3	Pt. 28 +
A2J5	4	Pt. 12 -	A4J5	4	Pt. 28 -
A2J6	1	Pt. 13 +	A4J6	1	Pt. 29 +
A2J6	2	Pt. 13 -	A4J6	2	Pt. 29 -
A2J6	3	Pt. 14 +	A4J6	3	Pt. 30 +
A2J6	4	Pt. 14 -	A4J6	4	Pt. 30 -
A2J9	1	Pt. 15 +	A4J9	1	Pt. 31 +
A2J9	2	Pt. 15 -	A4J9	2	Pt. 31 -
A2J9	3	Pt. 16 +	A4J9	3	Pt. 32 +
A2J9	4	Pt. 16 -	A4J9	4	Pt. 32 -

The connection between the digital output card and the field wiring is made with one of two cables:

HP 25550A (digital card cable with screw terminations)

HP 25550B (digital card cable, unterminated)

Section XI
HP 25514A 16-Point Relay Output

11.1 INTRODUCTION

This section provides information for the HP 25514A 16-Point Relay Output card. Included are specifications and a functional description. Installation information for the card is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

11.2 DESCRIPTION

The HP 25514A, shown in figure 11-1, provides 16 points of single-pole, double-throw (Form C) relay contacts which are individually isolated. The relays on the card are controlled separately, and the card supplies relay coil power. The 16-relays form one field of 16 points which can be controlled by an external strobe. To provide arc suppression, Signal Conditioning Modules (SCMs) are optionally mounted on the card in parallel to the relay contacts and the I/O connectors. Each SCM provides arc suppression for up to four relays. SCMs are available for several AC and DC voltage ranges.

The relays are rated for switching open-circuit voltages of up to 250 VAC at 1.5A, 125 VAC at 3.0A, and 30 VDC at 2.0A. Operating times are less than 15 milliseconds.

The relay output card is intended primarily for on/off switching of devices such as motor contactors, solenoid controllers, and power sources.

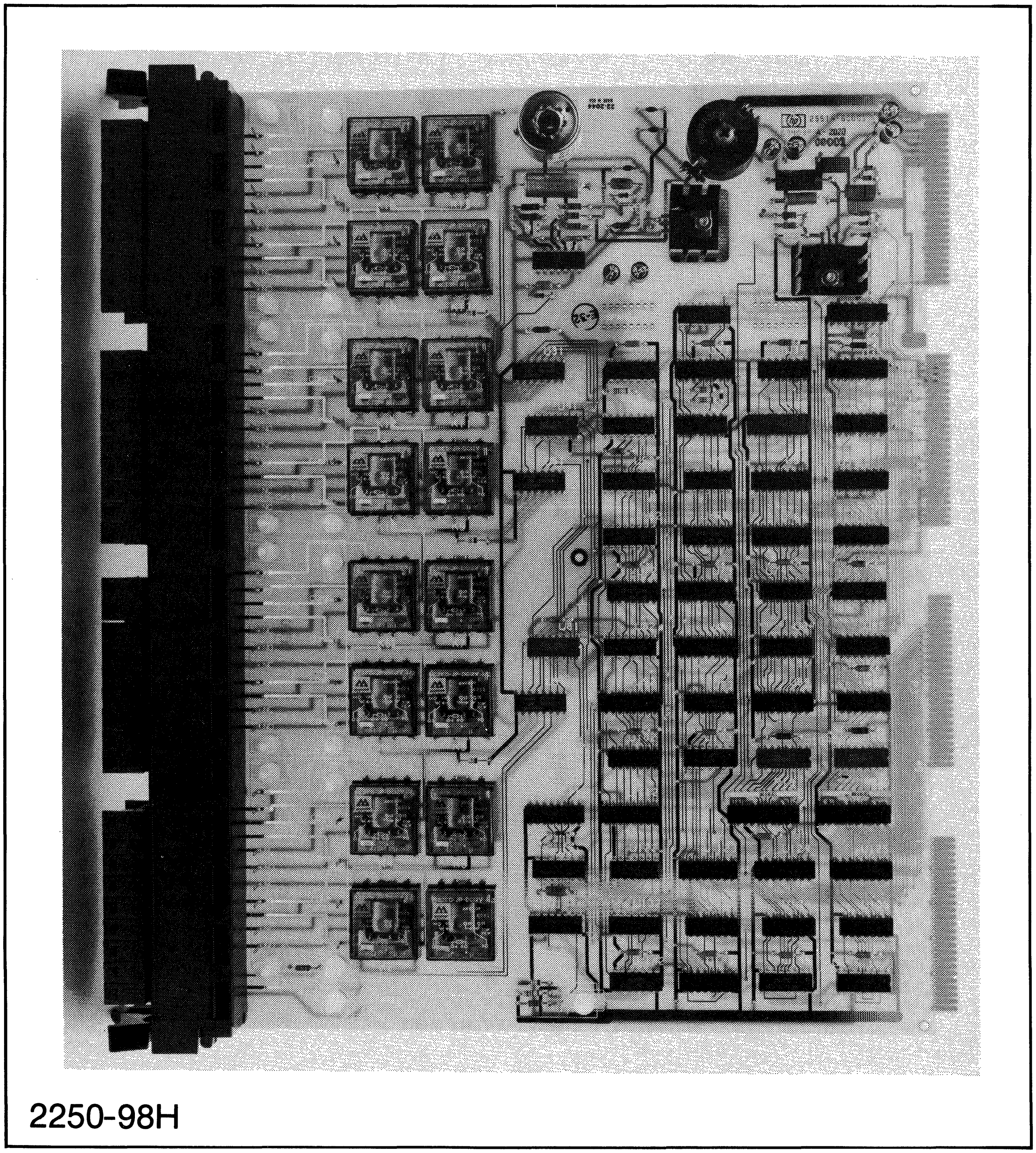


Figure 11-1. HP 25514A 16-Point Relay Output

11.3 SPECIFICATIONS

Specifications for the HP 25514A are provided in table 11-1.

Table 11-1. HP 25514A Specifications

FEATURES 16 channels of sealed Form C (SPDT) relays Relays can switch high (wet) or low (dry) current loads Switch 1.5A at 250 VAC 3.0A at 125 VAC 2.0A at 30 VDC Relay coil power supply on card - designed to isolate switching noise SCMs supply transient suppression to protect relays and prevent noise Relays can be programmed individually or as a 16-bit field External strobe can synchronize output changes to external event
APPLICATIONS Used to switch AC and DC loads on and off. Loads can be motor contactors, small motor pumps, heaters, lights, solenoids, and other loads using less than 1.5A at 250 VAC, 3A at 125 VAC, or 2A at 30 VDC.

Table 11-1. HP 25514A Specifications (Continued)

PROGRAMMING INFORMATION

A logic one written to an output energizes the relay (i.e., Normally Open (NO) contacts close and Normally Closed (NC) contacts open)

DO command:	Write sequential digital outputs
RDO command:	Read sequential digital outputs
FO command:	Write sequential digital output fields (16 bits)
RFO command:	Read sequential digital output fields (16 bits)

ELECTRICAL CHARACTERISTICS

Maximum digital update rate from buffer:

Sequential writes (point or field): 24 us/write

Maximum operate time (opening or closing): 15 msec

Maximum operate speed (see contact life data at end of this table): 10 - 30 cps

Maximum contact resistance: 0.5 ohm, measured from field wiring screw termination block.

Maximum carry current: 3.0A

Maximum resistive break current: 2A at 30 VDC
3A at 125 VAC
1.5A at 250 VAC

Minimum breakdown voltage: 1000 V VRMS between open contacts and between contact sets
1500 V RMS between contacts and coils

Maximum thermal offset: 100 uV at 25 degrees C

Minimum insulation resistance: 100 megohm between NO contact and NC contact at 500 VDC, 40 degrees C, 95 % relative humidity

Table 11-1. HP 25514A Specifications (Continued)

Maximum capacitance:	10 pF NC or NO to COMMON 10 pF contacts to coil
Crosstalk (Measured at the field wiring terminals with a 1 K ohm load):	
Channel to channel:	85 db at 60 Hz 65 db at 1 kHz
NO to NC:	70 db at 60 Hz 50 db at 1 kHz
External strobe input:	
Mimimum pulse width:	400 ns + pulse width of external strobe SCM
RELAY CONTACT LIFE	
Mechanical Life:	10^7 operations

Table 11-1. HP 25514A Specifications (Continued)

Relay Electrical Contact Life Versus Operating Conditions:

NO. OF OPERATIONS	BREAK CURRENT AMPS	CARRY CURRENT AMPS	OPEN CIRCUIT VOLTAGE VOLTS	OPERATING SPEED Hz
10^5	1.5	1.5	250 VAC	10
10^5	3.0	3.0	125 VAC	10
10^6	0.5	0.5	250 VAC	30
10^6	1.0	1.0	125 VAC	30
10^6	2.0	2.0	30 VDC	10
10^6	1.0	1.0	30 VDC	30
10^6	0.0	0.0	0.0 VDC	30
10^6	DRY	DRY	--	30
10^6	0.1	0.1	28 VDC	30

PHYSICAL CHARACTERISTICS:

Width: 28.91 cm (11.38 in.)

Depth: 34.8 cm (13.54 in.)

Height: 3.5 cm (1.38 in.)

Weight: 680 grams (1.5 lbs)

11.4 SIGNAL CONDITIONING

Arc suppression and single point isolated and non-isolated signal conditioning modules (SCMs) used with the HP 25514A are listed in table 11-2. Each arc suppression SCM contains arc suppression for both the NO and NC contacts of four relay points. The single point isolated and non-isolated SCMs are used for the External Strobe input.

The SCMs are mounted on the card before the card is installed in the measurement and control unit. Install the SCM, with its component side up, by aligning the guide holes in the SCM to the guide pins on the HP 25514A card, and pressing the SCM firmly into place. The physical orientation of the guide pins prevents improper installation of the SCM. The guide pins also serve as spacers to keep the SCM elevated from the surface of the card. Refere to the HP 2250 Installation and Start-Up Manual, part number 02250-90012, for further information on installing an SCM.

11.5 RELAY CONTACT RATINGS

Operation should not exceed the relay contact ratings listed in table 9-1. Note the different ratings for AC and DC circuits.

Warning

Do not apply opposite polarities (+ and -) to a pair of NC and NO contacts, because arcing upon switching may momentarily short between the NO and NC contacts.

Table 11-2. SCMs Available for Use with the HP 25514A

PRODUCT NUMBER	DESCRIPTION
HP 25531B	5 VDC Non-Isolated Source Strobe
HP 25531C	12 VDC Non-Isolated Source Strobe
HP 25531D	24 VDC Non-Isolated Source Strobe
HP 25531E	48 VDC Non-Isolated Source Strobe
HP 25531K	5 VDC Non-Isolated Sink Strobe
HP 25531L	12 VDC Non-Isolated Sink Strobe
HP 25533B	5 VDC Isolated Strobe
HP 25533C	12 VDC Isolated Strobe
HP 25533D	24 VDC Isolated Strobe
HP 25533E	48 VDC Isolated Strobe
HP 25533F	72 VDC Isolated Strobe
HP 25533G	120 VDC/72 VAC Strobe
HP 25533H	115 VAC Strobe
HP 25533J	230 VAC Strobe
HP 25539A	Relay Arc Suppression Breadboard
HP 25539E	30 VDC Load Relay Arc Suppression
HP 25539G	24 VAC Load Relay Arc Suppression
HP 25539H	115 VAC Load Relay Arc Suppression
HP 25539J	230 VAC Load Relay Arc Suppression
HP 25543N	60 VDC/42 VAC Isolated Output
HP 25544A	Open Drain, Non-Isolated Output
HP 25544B	5 VDC Non-Isolated Output
HP 25544C	12 VDC Non-Isolated Output
HP 25545P	115 VAC Isolated Output

11.6 RELAY OPERATING PRACTICE

For maximum relay life, observe good practice in relay operation; i.e., a relay operated with wet current (appreciable current through contacts) should not be later operated at dry current (insignificant current through contacts). Also, loads which have significant capacitance or inductance should employ arc suppression to prevent premature contact failure. Loads connected to the relay through a long cable should be considered inductive.

11.7 FUNCTIONAL DESCRIPTION

Figure 11-2 contains a functional block diagram showing the input/output buses and the major functions of the HP 25514A.

The processor unit "writes" relay output instructions to the card in one of two ways: one point at a time, or as a field of 16 points. The output field is sent as a field of 16 bits on all backplane lines, and single point data is sent on line D1.

The programmed states of the output relays (high or low logic levels) are stored in rank 1 of the Output Storage Registers and move to rank 2 when strobed. The rank 2 state is input to the 16 Relay Drivers. The drivers activate corresponding output relays. The output state can be read by the processor unit from rank 2.

You exercise control of the card functions through writing and reading data to and from the various registers. The registers are identified and described in Section III under "Register Addressing."

11.7.1 Output Relays

There are 16 Relay Drivers connected one-for-one to each bit of the Output Register. When a bit is "true", the associated relay is energized. They are connected so that Output Relay 1 is controlled by the least significant register bit and Relay 16 is controlled by the most significant register bit.

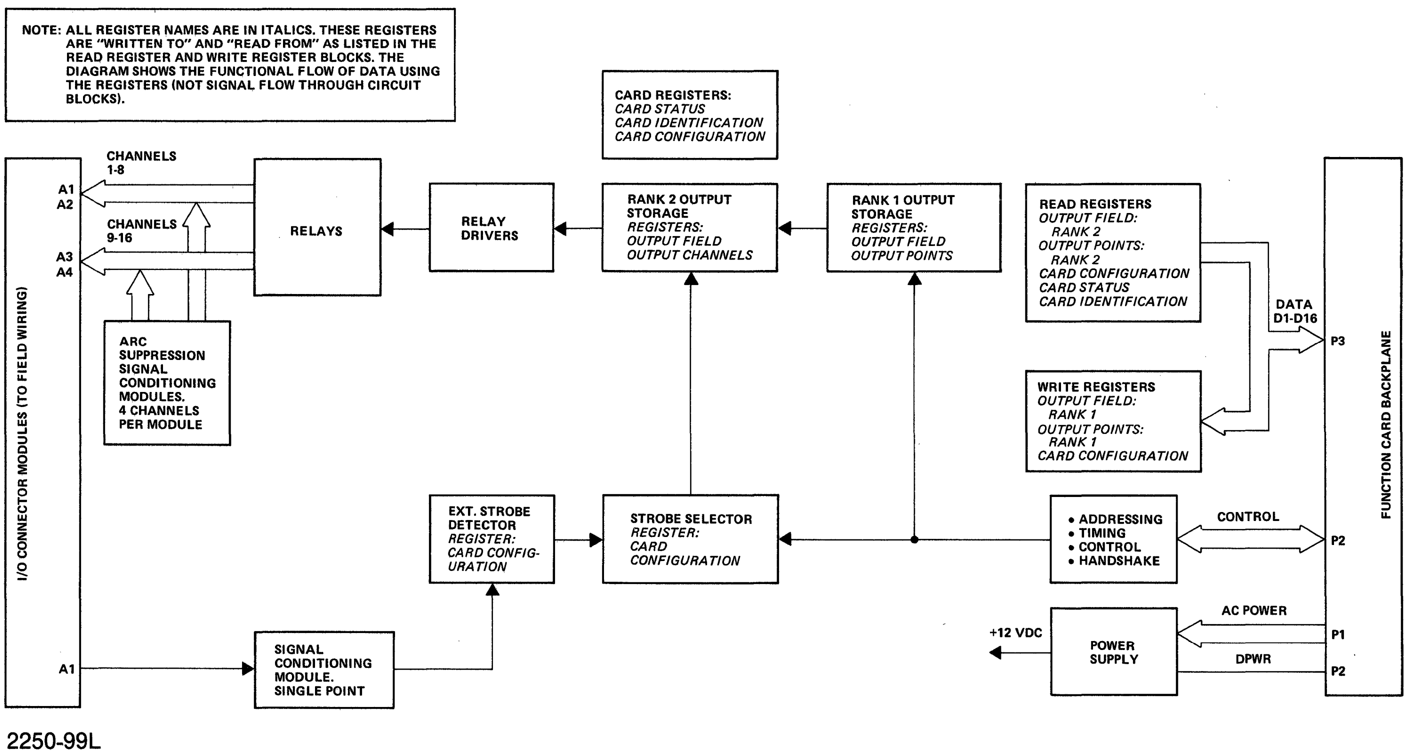


Figure 11-2. HP 25514A Functional Block Diagram

Relays with unenergized coils have their NO (Normally Open) contacts open, and their NC (Normally Closed) contacts closed. When energized, the relays switch to the opposite state. Initially at power on or processor unit reset, all relays will be deenergized; i.e., the data word in the output storage register will be all 0s.

11.7.2 Output Registers

There are two ranks for output field registers. Each rank has 16 bits corresponding to the 16 output relays. The relay state data written into rank 1 is moved to rank 2 so that the time of relay change can be precisely controlled.

Rank 1 state may be changed by a write command with new data. The data will be entered differently according to whether the controller called for a field change or a single point change. For a field change, all 16 points are represented in the data; i.e., all 16 bits in the output field are moved into rank 1. For a single point write, one bit is loaded into the rank 1 point addressed by the command.

When the data is written, it is stored in the first rank as soon as the output command is executed but it is not necessarily transferred immediately to the second rank which drives the output relays. A measurement strobe or measurement strobe plus external strobe, depending on internal or external strobe programming, is required. The measurement strobe can accompany the write command (write with measurement strobe) or it can be delayed (write without measurement strobe). Internal and external strobe timing is described below under State Timing.

11.7.3 State Readback

Output data is written to the card as a single word. An output register read returns the contents of the second rank (the output states). The read can be by the field or one point at a time. Because no shifting is required for a read, a subsequent instruction is never delayed.

The Card Status Register contains a "Strobe Wait" bit (Bit 0) which is set when new data has entered Output Field Register Rank 1, and clear when the new data has been strobed into Rank 2.

11.7.4 Timing

11.7.4.1 Register Timing

The card backplane overhead time (the time is takes to latch data in the card's input buffers and a handshake) takes a minimum of 10 microseconds. Additional time is used to store data into the output storage registers, so that the total time to move new data into the output rank 1 adds up to 24 microseconds. Since the output relays take up to 15 milliseconds to open or close, the backplane plus card delay time is insignificant.

If the card is addressed after it has accepted new data and before the data is stored in rank 1 of the output storage register, it will hold off the request until it is ready.

11.7.4.2 State Timing

In this discussion, an internal strobe refers to the internal measurement strobe, and an external strobe refers to an external measurement strobe provided by the user. These strobes are used for measurement timing as distinguished from other timing signals.

The external strobe is enabled on the card by writing a logic 1 into the LSB (Bit 0) of the Card Configuration Register.

The polarity of the external strobe is selected by the condition in Bit 8 of the Card Configuration Register. Assuming the external strobe mode is enabled, then a Logic 1 in bit 8 of the card configuration register will cause the output field to be strobed from rank 1 to rank 2 on the rising edge of the external strobe. Similarly, a Logic 0 in this bit strobes on the falling edge.

When the external strobe is disabled, a "write with internal strobe" stores new data in rank 1 and transfers it to rank 2 immediately. A "write without internal strobe" stores new data in rank 1 but the transfer of data from rank 1 to rank 2 is delayed until an internal strobe occurs.

Writing without an internal strobe allows several cards to be set up with new data, or several single channel changes to be made in several writes, and then the outputs on all the cards can be changed simultaneously.

With external strobe enabled, when a point or field is set up with a "write with internal strobe," the external strobe immediately following the internal strobe will transfer the rank 1 data to rank 2 and to the output.

However, if the card is set up with the external strobe enabled and a "write without internal strobe" is used to input new data into rank 1, the old state remains constant in rank 2. An internal strobe must activate the external strobe, then the next external strobe will move new data from rank 1 to rank 2. That is, an external strobe must be preceded by an internal strobe to be effective.

The examples in figure 11-3 show fields of data which are output with the card configured for both the internal strobe mode and external strobe mode with several conditions:

> The Configuration Register is written to, setting Bit 0=0, and the external strobe is disabled. Cycle 1 starts with a "write with internal strobe" command, and the transfer of Data 1 to the output is immediate.
>
> Cycle 2 begins with a "write without internal strobe" command, and the state is stored in rank 1, waiting for a strobe. Data 2 is output following the internal strobe which occurs in Cycle 3, since the data in rank 1 was not changed.
>
> The Configuration Register is written to, setting Bit 0=1 which enables the external strobe. Cycle 4 begins with a "write with internal strobe" and Data 4 is stored in rank 1. The stored data moves to rank 2 and output on the following external strobe.
>
> Cycle 5 begins with a "write without internal strobe and Data 5 is written into rank 1. The following external strobe has no effect on storing Data 5 in rank 2 since the internal strobe was omitted. In Cycle 6 the internal strobe is supplied, and the following external strobe moves Data 5 into rank 2 and the output.

OCCURRENCE	WRT *	EXTERNAL STROBE OFF			WRT *	EXTERNAL STROBE ON		
		CYCLE 1	CYCLE 2	CYCLE 3		CYCLE 4	CYCLE 5	CYCLE 6
Write Config.	0				1			
Write Data		1	2	NONE		4	5	NONE
Rank 1 Data		1	2	2		4	5	5
Meas. Strobe		^	NONE	^		^	NONE	^
Ext. Strobe						^	^	^
Rank 2 Data		1	1	2		4	4	5
Output		1	1	2		4	4	5
*Write to Configuration Register Bit 0.								

Figure 11-3. Examples of Output with Various Strobe Conditions

11.8 REGISTER ASSIGNMENTS

Register assignments for the relay output card are shown in table 11-3.

The relay output card reads no external inputs.

The register addresses on page 5 are the point output register addresses. Writing to these addresses will cause the corresponding output point to output the value of the lowest bit in the register (bit 0). Reading from these addresses will give the current output value of that point, which will be either 0 or 1.

The only address used on pages 9-12 is as shown. This address is for field output; writing to it will cause the written value to be output on points 1 through 16; reading from it will give the current output value for the field. The least significant bit corresponds to the lowest numbered point in the field.

The card configuration is used to configure the card for external strobe. The meaning of the bits is as follows.

Bit	Meaning
0	Enable strobe for Field 1
1-7	Undefined
8	If bit 0 is set, this bit controls which transition of the strobe to use. If bit 8 is set, the rising edge of the strobe is used. If bit 8 is clear, the falling edge of the strobe is used.
9-31	Undefined

There are two meaningful bits in the card status register. If bit 0 is set, field 1 is waiting for an external strobe signal or an internal trigger. If bit 15 is set, the card is busy.

TABLE 11-3. DIGITAL OUTPUT REGISTER ASSIGNMENTS

word 1 word 2 word 1 word 2 word 1 word 2 word 1 word 2

	PAGE 1	PAGE 2	PAGE 3	PAGE 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1	POINT 1			
2	POINT 2			
3	POINT 3			
4	POINT 4			
5	POINT 5			
6	POINT 6			
7	POINT 7			
8	POINT 8			
9	POINT 9			
10	POINT 10			
11	POINT 11			
12	POINT 12			
13	POINT 13			
14	POINT 14			
15	POINT 15			
16	POINT 16			

DIGITAL OUTPUT REGISTER ASSIGNMENTS, CONTINUED

word 1 word 2 word 1 word 2 word 1 word 2 word 1 word 2

	PAGE 9	PAGE 10	PAGE 11	PAGE 12
1				FIELD 1
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1				
2				
3				
4				
5				
6				
7				
8				
9				CARD CONFIG
10				0
11				CARD STATUS
12				0
13				CARD ID REG
14				0
15				0
16				BIF

11.9 PIN ASSIGNMENTS AND CABLING

Table 11-3 shows the signals that are routed to the card connector pins on the edge of the card. The connector numbering scheme is shown in figure 3-11, at the end of Section III of this manual.

Table 11-3. HP 25514A I/O Connector Module Pin Assignments

CONNECTOR	PINS	CONNECTION	CONNECTOR	PINS	CONNECTOR
A1J1	1,2	R=196 ohm	A3J1	1,2	R=196 ohm
A1J1	3	Strobe Gnd.	A3J1	3	NOT USED
A1J1	4	Fld.1 Strobe	A4J1	4	NOT USED
A1J2	1	NO1	A3J2	1	NO9
A1J2	2	COM1	A3J2	2	COM9
A1J2	3	NC1	A3J2	3	NC9
A1J2	4	COM1	A3J2	4	COM9
A1J5	1	NO2	A3J5	1	NO10
A1J5	2	COM2	A3J5	2	COM10
A1J5	3	NC2	A3J5	3	NC10
A1J5	4	COM2	A3J5	4	COM10
A1J6	1	NO3	A3J6	1	NO11
A1J6	2	COM3	A3J6	2	COM11
A1J6	3	NC3	A3J6	3	NC11
A1J6	4	COM3	A3J6	4	COM11
A1J9	1	NO4	A3J9	1	NO12
A1J9	2	COM4	A3J9	2	COM12
A1J9	3	NC4	A3J9	3	NC12
A1J9	4	COM4	A3J9	4	COM12
A2J1	1,2	R=196 ohm	A4J1	1,2	R=196 ohm
A2J1	3,4	N.C.	A4J1	3,4	N.C.
A2J2	1	NO5	A4J2	1	NO13
A2J2	2	COM5	A4J2	2	COM13
A2J2	3	NC5	A4J2	3	NC13
A2J2	4	COM5	A4J2	4	COM13
A2J5	1	NO6	A4J5	1	NO14
A2J5	2	COM6	A4J5	2	COM14
A2J5	3	NC6	A4J5	3	NC14
A2J5	4	COM6	A4J5	4	COM14
A2J6	1	NO7	A4J6	1	NO15
A2J6	2	COM7	A4J6	2	COM15
A2J6	3	NC7	A4J6	3	NC15
A2J6	4	COM7	A4J6	4	COM15
A2J9	1	NO8	A4J9	1	NO16
A2J9	2	COM8	A4J9	2	COM16
A2J9	3	NC8	A4J9	3	NC16
A2J9	4	COM8	A4J9	4	COM16

The connection between the relay output card and the field wiring is made with one of two cables:

HP 25550A (digital card cable with screw terminations)

HP 25550B (digital card cable, unterminated)

Section XII
HP 25516A 16-Point Digital Multifunction

12.1 INTRODUCTION

This section provides information for the HP 25516A 16-Point Digital Multifunction card. Included are specifications and a functional description. Installation information for the card is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

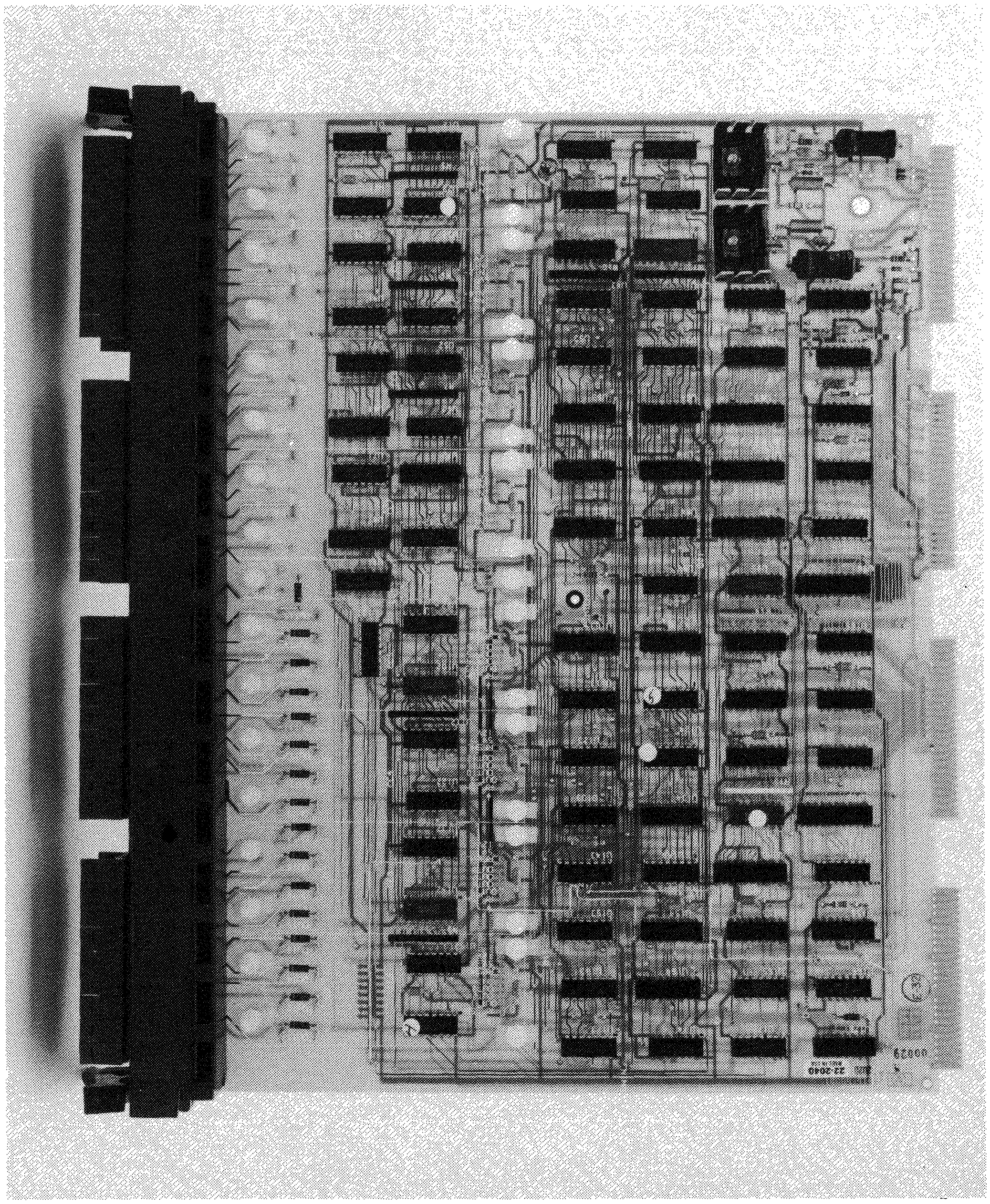
12.2 DESCRIPTION

The HP 25516A, shown in figure 12-1, provides 16 digital input points and 16 digital output points. The input points will detect input events and scale them according to programmed conditions. When the conditions are met, the processor unit is notified through an interrupt if the point is unmasked.

The conditions of the 16 input points for scaled events are independently defined. The conditions include direction of level change and the number of events per interrupt. All the event detection conditions, the input states and a record of interrupting points are stored in registers which can be read by the processor unit.

The storage of the input states for reading is timed by either an internal strobe signal, or by both the internal strobe and a user-supplied external strobe.

The 16 output points are individually programmable for controlling external events. Output data timing is determined by the internal strobe signal (there is no external strobe for output points).



2250-101H

Figure 12-1. HP 25516A 16-Point Digital Multifunction

Signal Conditioning Modules (SCMs) match external input and output conditions to the card requirements. (See the paragraph "SIGNAL CONDITIONING.")

12.3 SPECIFICATIONS

Specifications for the HP 25516A are provided in table 12-1.

Table 12-1. HP 25516A Specifications

FEATURES Event prescaling or totalizing to 256, independently programmable on each input point Paced mode Wide range of signal conditioning 16 digital input points 16 digital output points Point status and event sensing with programmable mask, sense, and sense override registers External strobe Two ranks of output storage
APPLICATIONS Monitors the state of mechanical or electronic switches, AC or DC coil/winding power on relays/motors, and instruments and transducers with digital outputs. Interrupts the processor unit upon occurrence of user-defined (programmable) events. Scales and totalizes events. Provides state switching of AC/DC loads.

Table 12-1. HP 25516A Specifications (Continued)

PROGRAMMING INFORMATION	
DO command:	Write sequential digital outputs
FO command:	Write sequential output fields
DI command:	Read sequential digital inputs
FI command:	Read sequential input fields
RDO command:	Read sequential digital outputs
RFO command:	Read sequential output fields
COUNT command:	Read current counts
PRESET command:	Write multifunction counter preset
RPRESET command:	Read counter preset
INT command:	Digital input interrupt conditions
ROLL command:	Set multifunction counter rollover
SENSE command:	Define interrupt transition sense
SOVER command:	Override transition sense for interrupts

ELECTRICAL CHARACTERISTICS	
Minimum detectable input pulse width (external strobe input):	1 us
Minimum detectable input pulse width (other inputs):	16 us
Minimum setup time of data with respect to active strobe edge:	0
Minimum hold time of data with respect to active strobe edge:	16 us

Note that in order to determine overall card specifications, those of the particular SCM used must be considered. For example, using the HP 25535 Non-Isolated Digital Input SCM with minimum and maximum propagation delays of 0 and 28 usec, respectively (without the filter), the overall minimum detectable input pulse width for the external strobe input becomes 28 usec + 1 usec = 29 usec. This is for the worst case in which the propagation delay in one direction is 0 and in the other direction is 28 usec.

Table 12-1. HP 25516A Specifications (Continued)

PHYSICAL CHARACTERISTICS	
Width:	28.91 cm (11.38 in.)
Depth:	34.8 cm (13.54 in.)
Height:	3.5 cm (1.38 in.)
Weight:	680 grams (1.5 lbs)

12.4 SIGNAL CONDITIONING

Signal conditioning modules (SCMs) determine the number of points per I/O connector module, and the number of points available. SCMs for DC outputs contain four points, and SCMs for AC outputs contain two points. (AC SCMs divide the number of available points by two.). Both AC and DC SCMs can be installed on the same card. Table 12-2 lists SCMs used with the HP 25516A. Additional information on the SCMs is contained in Sections III and XIV.

On the output field, there are two terminals per point, which differ in location on the I/O connection modules according to whether it is an AC or a DC point. The terminals for DC points may be used for reference in location terminals for AC points.

DC SCMs have plus and minus connections (the minus connection is ground in non-isolated SCMs), and AC SCMs have two non-polarized terminals. The AC terminal pairs correspond with the odd-numbered plus (+) DC terminals and the even-numbered minus (-) DC terminals. For example, an AC SCM may connect to the termnals corresponding to DC point 1 (+) to DC point 2 (-), and another from DC point 3 (+) to DC point 4 (-). AC and DC SCMs can be mixed in the same field.

AC SCMs output data is addressed to the odd-numbered (+) DC point register locations. If an even-numbered DC point register location addressed which is connected to an AC SCM, there will be no output response. This should be kept in mind in order to facilitate the programming of sequential points; i.e., group the AC and DC SCMs together. Be sure to identify the terminals of any two-point AC SCMs to prevent errors in field wiring and programming.

Table 12-2. SCMs Available for Use with the HP 25516A

PRODUCT NUMBER	DESCRIPTION
HP 25531B	5 VDC Non-Isolated Source Strobe
HP 25531C	12 VDC Non-Isolated Source Strobe
HP 25531D	24 VDC Non-Isolated Source Strobe
HP 25531E	48 VDC Non-Isolated Source Strobe
HP 25531K	5 VDC Non-Isolated Sink Strobe
HP 25531L	12 VDC Non-Isolated Sink Strobe
HP 25533B	5 VDC Isolated Strobe
HP 25533C	12 VDC Isolated Strobe
HP 25533D	24 VDC Isolated Strobe
HP 25533E	48 VDC Isolated Strobe
HP 25533F	72 VDC Isolated Strobe
HP 25533G	120 VDC/72 VAC Strobe
HP 25533H	115 VAC Strobe
HP 25533J	230 VAC Strobe
HP 25535B	5 VDC Non-Isolated Source Input
HP 25535C	12 VDC Non-Isolated Source Input
HP 25535D	24 VDC Non-Isolated Source Input
HP 25535E	48 VDC Non-Isolated Source Input
HP 25535K	5 VDC Non-Isolated Sink Input
HP 25535L	12 VDC Non-Isolated Sink Input
HP 25537P	5 VDC Isolated Input
HP 25537Q	12 VDC Isolated Input
HP 25537R	24 VDC/16 VAC Isolated Input
HP 25537S	48 VDC Isolated Input
HP 25537T	72 VDC Isolated Input
HP 25537U	120 VDC/72 VAC Isolated Input
HP 25537V	115 VAC Isolated Input
HP 25537W	230 VAC Isolated Input

Table 12-2. SCMs Available for Use with the HP 25516A (Continued)

HP 25539A HP 25539E HP 25539G HP 25539H HP 25539J	Relay Arc Suppression Breadboard 30 VDC Load Relay Arc Suppression 24 VAC Load Relay Arc Suppression 115 VAC Load Relay Arc Suppression 230 VAC Load Relay Arc Suppression
HP 25543N	60 VDC/42 VAC Isolated Output
HP 25544A HP 25544B HP 25544C	Open Drain, Non-Isolated Output 5 VDC Non-Isolated Output 12 VDC Non-Isolated Output
HP 25545P	115 VAC Isolated Output

The ID for the HP 25516A card is decimal 16. This number is contained in Card Register 253 and may be read as data when addressed.

SCMs must be mounted on the card before it is installed into the processor or expander card frame. Install the SCM, with its component side up, by aligning the guide holes in the SCM to the guide pins on the HP 25516A card, and pressing the SCM firmly into place. The physical orientation of the guide pins prevents improper installation of the SCM. The guide pins also serve as spacers to keep the SCM elevated from the surface of the card. Refer to the HP 2250 Installation and Start-Up Manual, part number 02250-90012, for further information on installing SCMs.

12.5 FUNCTIONAL DESCRIPTION

Figure 12-2 contains a functional block diagram showing the input/output buses and the major functions of the HP 25516A.

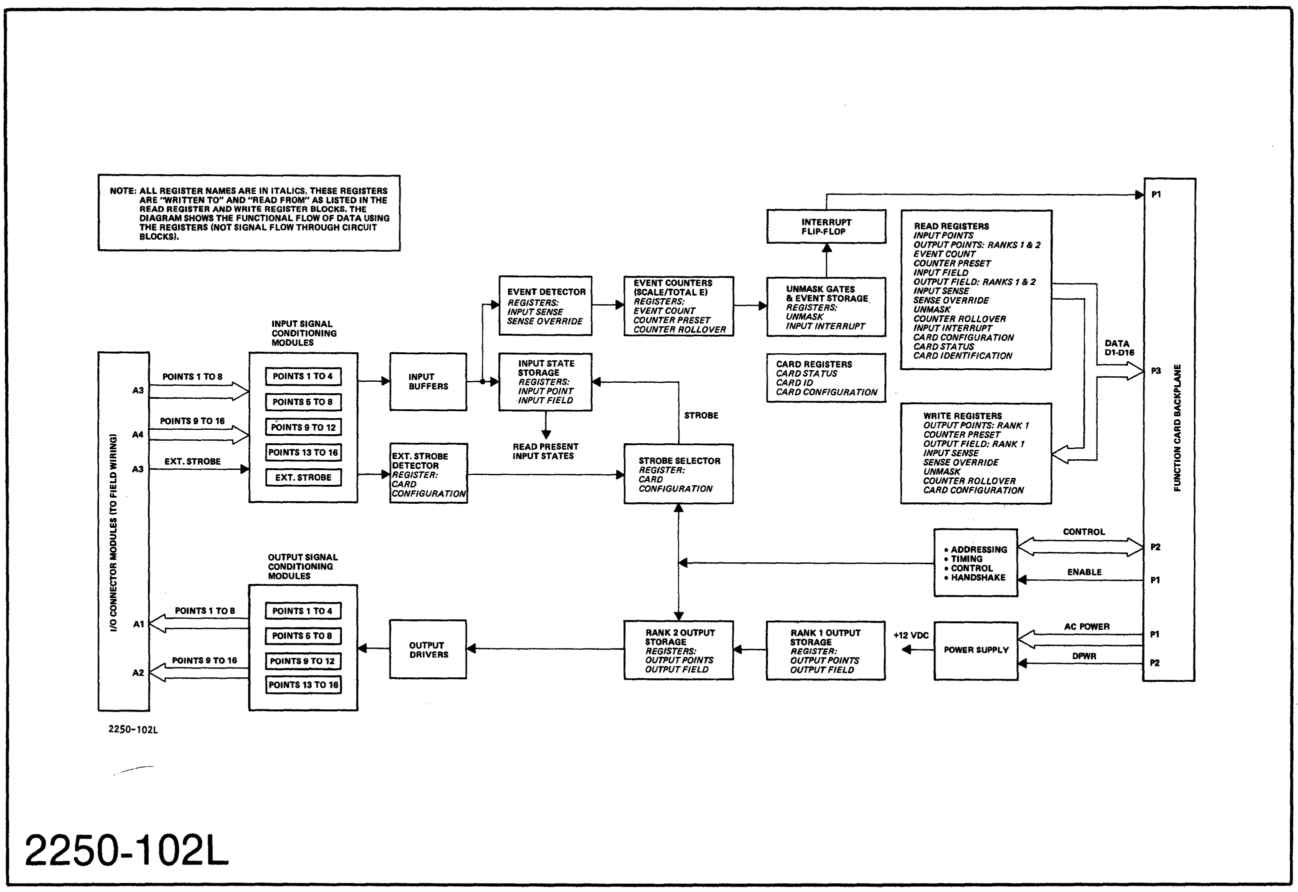


Figure 12-2. HP 25516A Functional Block Diagram

The card has a field of 16 digital input points with an external strobe, and a field of 16 digital output points. The inputs and outputs connect to the external field wiring through signal conditioning modules (SCMs).

For the output field, the programmed states of the points (high or low levels) are stored in Rank 1 of the Output Field Register and are moved to Rank 2 when internally strobed. Rank 2 drives the output lines.

The present states of the input points may be read at any time. In addition to monitoring the present states, the input points independently detect events by comparing the past states with the present states, and determining if any state has changed in a selected direction. (For example, low levels changed to high, or high levels changed to low.) Events for each point are counted with a presettable counter. When the counter overflows, if the point is "unmasked," its corresponding bit in the Interrupt Register will be set and an interrupt signal will be sent to the processor unit.

The interrupt record of scaled events for the input points is saved until read by the processor unit, which resets the record to zero and clears the interrupt signal.

Figure 12-2 also shows every user-accessible card register which affects the data flow. The following description covers the function of each register in the overall operation of the card. You exercise control of the card functions through writing and reading data to and from the various registers. The registers are identified and described in Section III under "Register Addressing."

12.5.1 Output Point Data

You may write output point data either one point at a time to the appropriate output point register, or 16 points concurrently as a field to the output field register. A logic 1 closes the output switch, and a logic 0 opens (clears) it. The data word in the output point registers is all 0s when all points are clear. Initially at "power on" or processor unit reset, all outputs will be open (clear).

For the 16-bit output field register, the 1 or 0 value of each bit is the data for the corresponding output point. The least significant bit corresponds with the lowest numbered point, the next least significant bit corresponds with the next to the lowest numbered point, etc.

The output field (output point data) is moved through two stages (or ranks) of the Output Field Register to reach the output lines. When the data is written, it is stored in the first rank as soon as the command is transmitted but it is not necessarily transferred immediately to the second rank. The second rank drives the output switches. An internal strobe is required to transfer the data to the second rank. The internal strobe normally is issued at the same time that data transfers to the card; thus, the data normally goes immediately to the second rank of storage which drives the output switches.

However, the internal strobe can be delayed by requesting a "write without internal strobe." Transfer takes place only when the delayed internal strobe occurs. This method of programming allows several cards to be set up with data in the first rank, and then the output on all the cards can be changed simultaneously. The delayed strobe also allows the contents of the first rank to be read for error checking before transfer to the output.

Output data is written to the card as a single word. However, the output registers may be read as one- or two-word registers. A one-word register read returns the contents of the second rank (the output states). A two-word register read returns the contents of the second rank in word one and the contents of the first rank in word two.

As noted previously, the output lines connect to the field wiring through AC and DC SCMs. AC SCMs cover two points each and DC SCMs cover four points each.

12.5.2 Input Point Data

Inputs from the field wiring enter the card through SCMs. Each input SCM accomodates four contiguous points and four modules to cover the 16-point field. SCMs are selected to match signal levels, and to provide signal isolation, if desired. Several different types and ranges may be selected (see table 12-2).

An external strobe can be employed to determine when the input states will be stored in the Input State Storage Registers. Thus, you can ensure that only valid data is being input after external adjustments have been made. The input voltage on each point at the moment a strobe occurs becomes the current or present state of that point. The external strobe is used only for reading the input states and has no effect on event detection. Event detection is performed by an independent circuit that samples the input state every 16 microseconds. Nothing is allowed to interfere with this sampling.

Whether or not the external strobe is used to specify when inputs are valid, the time at which the valid inputs are read is determined by an internal strobe. This internal strobe is normally issued at the time of the read command; however, it can be delayed in order to set up several cards to be read at the same time. The cards are read when they are strobed concurrently.

12.5.3 Status Readback

The Card Status Register contains a "Strobe Wait" bit (Bit 0). When this bit is set, it indicates that the previous data has been read and the field is ready to receive new data. When this bit is clear, the card has previous input data which has not been read.

12.5.4 Event Detection

An event occurs when an input changes state either in a specified direction (sense register), or both directions (sense override register). Events are accumulated by a counter. When the counter overflows on an unmasked point, the occurrence is recorded in the Interrupts Register. If it is the first event in a series (the register was previously cleared) an interrupt goes to the processor unit.

Each of the 16 Preset and Count Registers contain data for one of the 16 points, The event detection registers contain one bit of information for each of the 16 points. The event detection registers are the following:

SENSE REGISTER: Selects one of two directions for events.

SENSE OVERRIDE REGISTER: Allows both directions for events when set.

EVENT COUNT REGISTERS: Contains value of 256 minus the number of events remaining before the count overflows (16 registers).

COUNTER PRESET REGISTERS: Contains preset value for corresponding event counter (16 registers).

ROLLOVER REGISTER: Each bit directs corresponding event counter to either rollover to zero or jump to preset value when it overflows.

UNMASK REGISTER: Selects which points may cause an interrupt.

INTERRUPTS REGISTER: Records which unmasked points reached the prescribed number of events.

An input change is detected by examining each input, in sequence, every 16 microseconds to determine if the present state differs from the past state. The event detector compares the direction of change with the desired direction of change as specified in the Sense Register and Sense Override Register. The sense bit is a logic 1 for a low-to-high change to be an event, and a logic 0 for a high-to-low change to be an event. Thus if the changed point has a present state of 1 and the sense is 1, the change was from low-to-high and the sense is correct for an event. Conversely, if the changed point has a present state of 0 and the sense is 0, the change was from high-to-low and the sense is correct for an event. Opposite changes will not result in events.

If the corresponding bit in the Sense Override Register is set to a logic 1, the effect of the sense bit will be cancelled so that all changes will qualify as events. To summarize, if either the sense override bit is set or the present state is the same as the sense bit, an event has occurred if the present state differs from the past state.

12.5.5 Event Counting and Scaling

There is an independent counter for each of the 16 input points to scale events. They count either from zero or a preset value up to 255. After another count a counter's next number depends on the contents of the Counter Rollover Register which sets up the "totalize" mode or "prescale" mode.

The "prescale" mode should be selected for repeatedly counting the same number of events on a point; i.e., the counter automatically restarts at the preset value as soon as the selected count is reached. The "totalize" mode should be selected if automatic restart at the preset value is not wanted. In the "totalize" mode, the counter continues counting up from zero, thus keeping a record of the number of additional events that occur.

The "prescale" mode is selected for a counter when a bit corresponding to its input point in the 16-bit Rollover Register is 1. When a number is written into a Counter Preset Register, the corresponding counter is preset with that value, which is equal to 256 minus the desired number of counts to qualify as a scaled event. After the desired number of counts, the counter jumps to the preset number and sends a "scaled event" bit to the Unmask Gates and Events Storage circuit.

The "totalize" mode is selected for a counter when a bit corresponding to its input point in the 16-bit Rollover Register is a logic low (0). In this mode, the count starts from a preset number which was stored in a corresponding Counter Preset Register from a previous write. When the count reaches 255, the next count will always rollover to 0 and continue counting events. When the counter rolls over, it sends a "scaled event" bit to the Unmasked Gates and Events Storage circuit.

12.5.6 Unmasking Scaled Events

When a "scaled event" bit for an input point is generated in one of the counters, it is checked with a bit in the Unmask Register. The Unmask Register is a 16-bit register with bits corresponding to the input field. If the bit is (1), the point is "unmasked" and the bit is passed through and recorded for that point in the Interrupt Register. If the bit is (0), the point is "masked" and the scaled event bit is not passed through.

12.5.7 Interrupt Recording

A scaled event bit is stored in the Interrupt Register if it is the first one after a register reset to zero. If a bit for that point is already stored, nothing is changed by another scaled event bit. The first scaled event for any point after a reset to zero will set the Interrupt Flip-Flop which notifies the processor unit, through the function card backplane, that a scaled event has occurred. The card's Interrupt Enable bit must be set in order for the interrupt to propagate through to the processor unit.

Both the Interrupt Register and Interrupt Flip-Flop are reset, or cleared, when the Interrupt Register is read. The clearing is done in such a way that any scaled event occurring during the read and clear will not be lost. It will either be included in the simultaneously occurring read, or it will be stored in the register for the next read.

12.5.8 Event Detection

An event will be detected according to the summary shown in figure 12-3. The figure shows changes in input signal level versus corresponding register bits, and whether an event resulted.

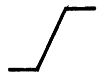
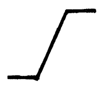
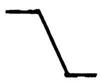
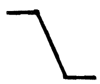
INPUT SIGNAL	SENSE OVERRIDE	SENSE	EVENT
	1	0 or 1	YES
	1	0 or 1	YES
	0	1	YES
	0	1	NO
	0	0	YES
	0	0	NO

Figure 12-3. Event Detection Summary

12.5.9 Event Scaling

For the following example, assume the following:

Conditions:

Interrupt after every third event on point 1 (prescale), and interrupt after the fourth event on point 2 but not after the subsequent events on that point (totalize).

Set Up:

Set point 1 to prescale mode (rollover bit 1= 1), enter preset 253 into Counter Preset Register 1. Set point 2 to totalize mode (rollover bit 2= 0), enter preset 252 into Counter Preset Register 2.

Operation:

1. Point 1 counter will count from 253. The third count will generate a scaled-event bit to the interrupt register, jump back to 253, and repeat every three event counts.

2. Point 2 counter will count from 252. The fourth count will generate a scaled-event bit to the interrupt register, and roll over to zero. It will not roll over again until 256 additional events are counted.

The above operation is illustrated below:

```
Point 1:
Input               X     X     X     X     X     X     X     X
Count           253   254   255   253   254   255   253   254   255
Scaled Event                      X                 X

Point 2:
Input               X     X     X     X   X    X    X    X    X
Count           252   253   254   255   0    1    2    3    4    5
Scaled Event                            X
```

If one or more scaled events are recorded on a single point between readings of the Interrupt Register (resets to zero), no record is available of how many such events occurred. However, there is a record of what points of the field of 16 have had one or more events since the last reading.

12.5.10 Timing

12.5.10.1 Input Timing

The Card Configuration Register is used to select either the non-external mode or external strobe mode and the strobe polarity. Bit 0 determines the strobe mode where a logic 0 selects the "non-external strobe" mode and logic 1 selects the "external strobe" mode. The external strobe polarity is selected by Bit 8 where logic 1 latches the input states on the rising edge of the strobes, and logic 0 latches the inputs on the falling edge of the strobes.

There are two program variations for strobes to input data, store it in a register, and read it. This is to provide commands to "read with internal strobe" or "read without internal strobe" for immediate or delayed data reading, respectively.

Figure 12-4 illustrates the non-external strobe mode where the internal strobe stores the input data. As in cycle 1, every time there is an internal strobe and a read command together (read with internal strobe), the present data is returned as valid data. As in cycle 2, when the internal strobe is omitted (read without internal strobe) the previous data (cycle 1) is returned since no new data was stored. The "read without internal strobe" will cause data to be input on the next internal strobe but from then on the internal strobe is disabled until the stored data is read, as shown in cycles 3 through 5. The internal strobe is reenabled for cycle 6 since the data was read in cycle 5. Optionally, cycle 6 may have a "read with internal" strobe to return data immediately, or the read command may be omitted for delayed reading as shown.

When a field or point has been configured to the external strobe mode, the operation is similar to the non-external strobe mode, described above, except that the external strobe substitutes for the internal strobe to input data. External strobe operation is illustrated in figure 12-5.

In cycle 1 there is an external strobe and data is input. This data is read using the "read with internal strobe" command. In cycle 2 data is input with the external strobe but this time a "read without internal strobe" command is used. Therefore, the next external strobe inputs data as shown in cycle 3, and since there is no read command the external strobe is ignored in cycles 4 and 5. A read command in cycle 5 returns the stored data of cycle 3 and reenables the external strobe for cycle 6.

NO EXT. STROBE MODE (CONFIG. REG.: FLD. 1 BIT 0=0 OR FLD. 2 BIT 1=0						
OCCURRENCE (FIELD 1 OR FIELD 2)	IMMEDIATE READ	NO STROBE	DELAYED READ			REENABLED STROBE
	CYCLE 1	CYCLE 2	CYCLE 3	CYCLE 4	CYCLE 5	CYCLE 6
Input Data	1	2	3	4	5	6
Internal Str	▲	NONE	▲	▲	NONE	▲
Input Read	▲	▲	NONE	NONE	▲	NONE
Stored Data	1	1	3	3	3	6
Data Read	1	1	NONE	NONE	3	NONE

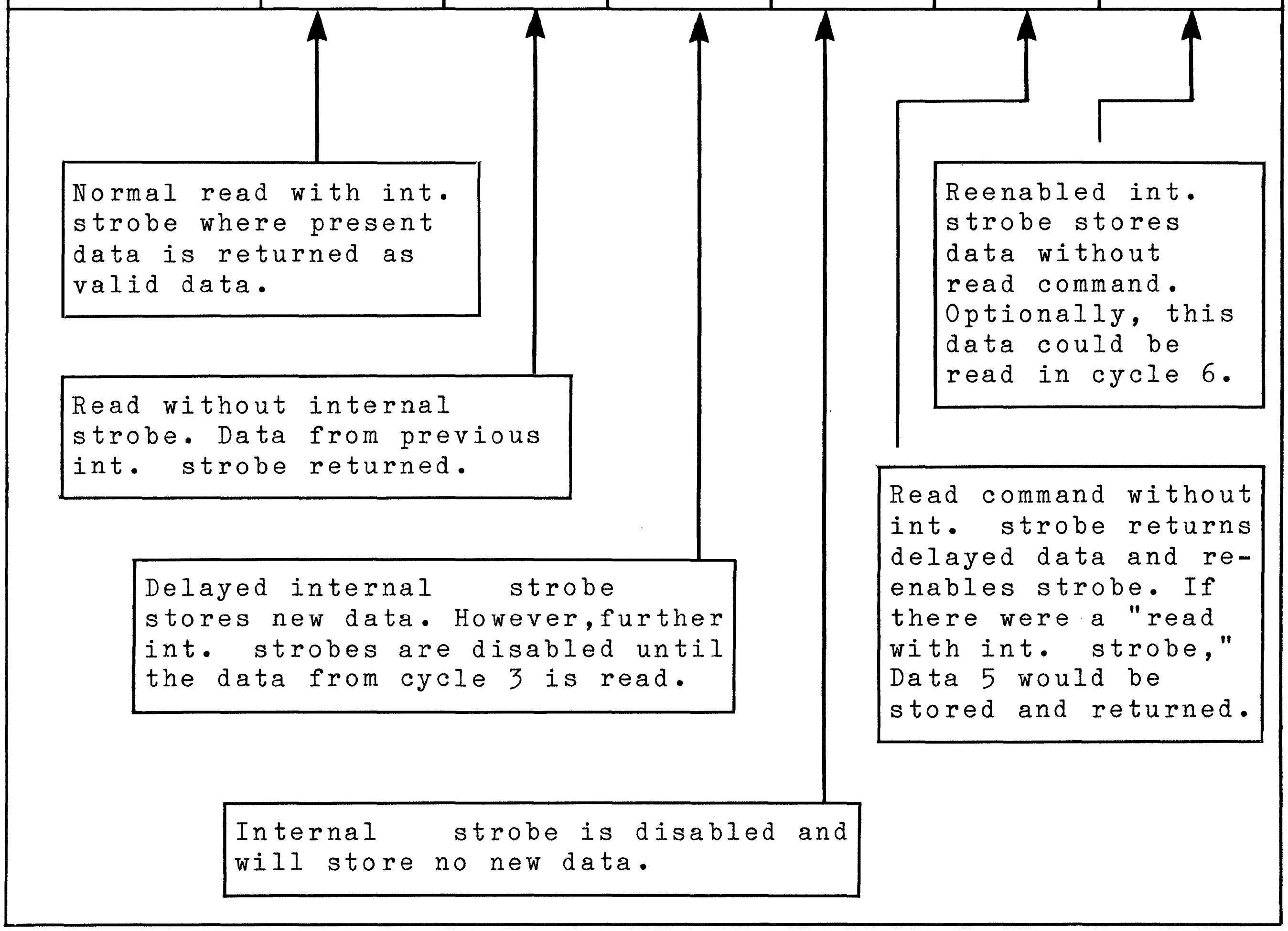


Figure 12-4. Non-External Strobe Mode Operation

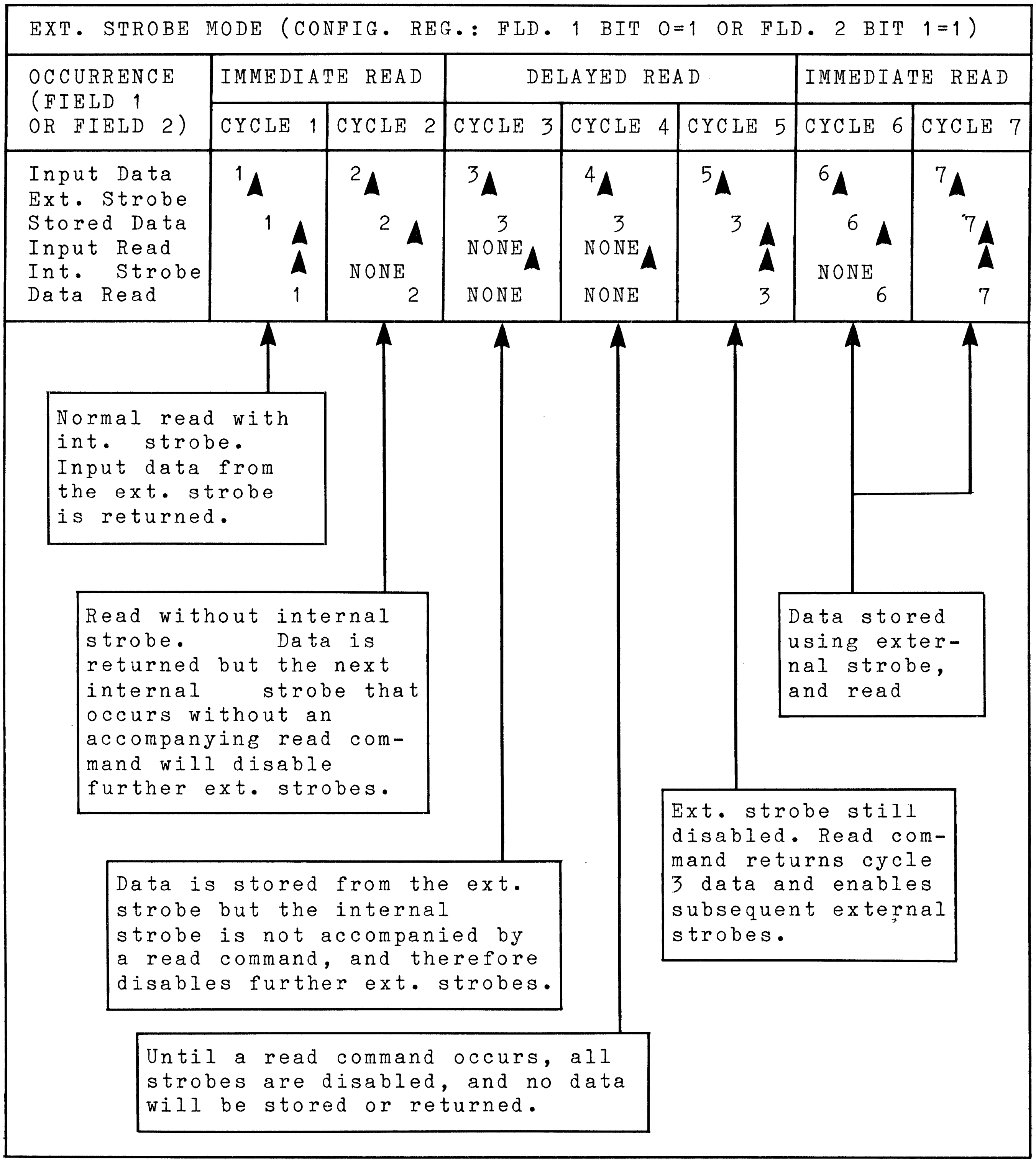


Figure 12-5. External Strobe Mode Operation

12.6 REGISTER ASSIGNMENTS

Register assignments for the digital multifunction card are shown in table 12-3.

The digital multifunction card has one input field and one output field. The addresses on page 1 are the input point register addresses; reading from these addresses returns the current input value of the corresponding point.

Writing to the addresses on page 5 will cause the output of the corresponding output point to be the value of the lowest bit of the data written to the corresponding address. Reading from these addresses will return the current value of the output from the corresponding point.

The count associated with each input point is available by reading from the addresses on page 9. The preset for these counters is written to and read from the addresses on page 10. The current input field and output field values are available from the addresses on pages 11 and 12, as shown in the diagram below.

The sense and enable registers for configuring interrupts on the input field are accessible through the first addresses on pages 14 and 15, and the interrupt status and card function register addresses are on page 16. Whenever the interrupt register is read, it is cleared automatically.

The rollover register on page 13 is used to determine what value to load the multifunction counters with when the counter overflows. Each bit in the rollover register corresponds to a point counter. If the counter's rollover bit is set, it rolls over to the value in the preset register; if the bit is clear, it rolls over to 0.

The card configuration register of the multifunction card is used to configure the card for external strobe.

Bit	Meaning
0	Enable External Strobe
1-7	Undefined
8	If bit 0 is set, this bit configures which transition of the strobe signal is valid. If bit 8 is set, the data is strobed on the next rising edge. If bit 8 is clear, the data is strobed on the next falling edge.
9-31	Undefined

The card status register has only one significant bit. If bit 0 is set, the the field is waiting for an external strobe or an internal trigger.

TABLE 12-3. MULTIFUNCTION CARD REGISTER ASSIGNMENTS

	word 1 word 2	word 1 word 2	word 1 word 2	word 1 word 2
	PAGE 1	PAGE 2	PAGE 3	PAGE 4
1	INPOINT 1			
2	INPOINT 2			
3	INPOINT 3			
4	INPOINT 4			
5	INPOINT 5			
6	INPOINT 6			
7	INPOINT 7			
8	INPOINT 8			
9	INPOINT 9			
10	INPOINT 10			
11	INPOINT 11			
12	INPOINT 12			
13	INPOINT 13			
14	INPOINT 14			
15	INPOINT 15			
16	INPOINT 16			

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1	OUTPOINT 1			
2	OUTPOINT 2			
3	OUTPOINT 3			
4	OUTPOINT 4			
5	OUTPOINT 5			
6	OUTPOINT 6			
7	OUTPOINT 7			
8	OUTPOINT 8			
9	OUTPOINT 9			
10	OUTPOINT 10			
11	OUTPOINT 11			
12	OUTPOINT 12			
13	OUTPOINT 13			
14	OUTPOINT 14			
15	OUTPOINT 15			
16	OUTPOINT 16			

TABLE 12-3. MULTIFUNCTION CARD REGISTER ASSIGNMENTS, CONTINUED

word 1 word 2 word 1 word 2 word 1 word 2 word 1 word 2

128	PAGE 9	PAGE 10	PAGE 11	PAGE 12
1	COUNT 1	PRESET 1	INFIELD 1	OUTFIELD 1
2	COUNT 2	PRESET 2		
3	COUNT 3	PRESET 3		
4	COUNT 4	PRESET 4		
5	COUNT 5	PRESET 5		
6	COUNT 6	PRESET 6		
7	COUNT 7	PRESET 7		
8	COUNT 8	PRESET 8		
9	COUNT 9	PRESET 9		
10	COUNT 10	PRESET 10		
11	COUNT 11	PRESET 11		
12	COUNT 12	PRESET 12		
13	COUNT 13	PRESET 13		
14	COUNT 14	PRESET 14		
15	COUNT 15	PRESET 15		
16	COUNT 16	PRESET 16		

191

192	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1	ROLLOVER	SENSE	UNMASK	INTERRUPTS
2	0	0	0	0
3		OVERRIDE		
4		0		
5				
6				
7				
8				
9				CARD CONFIG
10				0
11				CARD STATUS
12				0
13				CARD ID REG
14				0
15				0
16				BIF

255

12.7 PIN ASSIGNMENTS AND CABLING

Table 12-3 shows the signals that are routed to the card connector pins on the edge of the card. The connector numbering scheme is shown in figure 3-11, at the end of Section III of this manual.

Table 12-3. HP 25516A I/O Connector Module Pin Assignments

CONNECTOR	PINS	CONNECTION	CONNECTOR	PINS	CONNECTION
A1J1	1,2	178-ohm res.	A3J1	1,2	147-ohm res.
A1J1	3	N.C..	A3J1	3	Fld. 2 Strobe
A1J1	4	NOT USED	A3J1	4	Strobe Gnd.
A1J2	1	Out Pt. 1 +	A3J2	1	In Pt. 1 +
A1J2	2	Out Pt. 1 -	A3J2	2	In Pt. 1 -
A1J2	3	Out Pt. 2 +	A3J2	3	In Pt. 2 +
A1J2	4	Out Pt. 2 -	A3J2	4	In Pt. 2 -
A1J5	1	Out Pt. 3 +	A3J5	1	In Pt. 3 +
A1J5	2	Out Pt. 3 -	A3J5	2	In Pt. 3 -
A1J5	3	Out Pt. 4 +	A3J5	3	In Pt. 4 +
A1J5	4	Out Pt. 4 -	A3J5	4	In Pt. 4 -
A1J6	1	Out Pt. 5 +	A3J6	1	In Pt. 5 +
A1J6	2	Out Pt. 5 -	A3J6	2	In Pt. 5 -
A1J6	3	Out Pt. 6 +	A3J6	3	In Pt. 6 +
A1J6	4	Out Pt. 6 -	A3J6	4	In Pt. 6 -
A1J9	1	Out Pt. 7 +	A3J9	1	In Pt. 7 +
A1J9	2	Out Pt. 7 -	A3J9	2	In Pt. 7 -
A1J9	3	Out Pt. 8 +	A3J9	3	In Pt. 8 +
A1J9	4	Out Pt. 8 -	A3J9	4	In Pt. 8 -
A2J1	1,2	178-ohm res.	A4J1	1,2	147-ohm res.
A2J1	3,4	NOT USED	A4J1	3,4	NOT USED
A2J2	1	Out Pt. 9 +	A4J2	1	In Pt. 9 +
A2J2	2	Out Pt. 9 -	A4J2	2	In Pt. 9 -
A2J2	3	Out Pt. 10 +	A4J2	3	In Pt. 10 +
A2J2	4	Out Pt. 10 -	A4J2	4	In Pt. 10 -
A2J5	1	Out Pt. 11 +	A4J5	1	In Pt. 11 +
A2J5	2	Out Pt. 11 -	A4J5	2	In Pt. 11 -
A2J5	3	Out Pt. 12 +	A4J5	3	In Pt. 12 +
A2J5	4	Out Pt. 12 -	A4J5	4	In Pt. 12 -
A2J6	1	Out Pt. 13 +	A4J6	1	In Pt. 13 +
A2J6	2	Out Pt. 13 -	A4J6	2	In Pt. 13 -
A2J6	3	Out Pt. 14 +	A4J6	3	In Pt. 14 +
A2J6	4	Out Pt. 14 -	A4J6	4	In Pt. 14 -
A2J9	1	Out Pt. 15 +	A4J9	1	In Pt. 15 +
A2J9	2	Out Pt. 15 -	A4J9	2	In Pt. 15 -
A2J9	3	Out Pt. 16 +	A4J9	3	In Pt. 16 +
A2J9	4	Out Pt. 16 -	A4J9	4	In Pt. 16 -

The connection between the digital multifunction card and the field wiring is made with one of two cables:

HP 25550A (digital card cable with screw terminations)

HP 25550B (digital card cable, unterminated)

Section XIII
HP 25594 Thermocouple Reference Connector

13.1 INTRODUCTION

This section provides information for the HP 25594 Thermocouple Reference Connector (TRC). Included are specifications and a functional description. Installation information for the connector is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

13.2 DESCRIPTION

The HP 25594 (TRC), shown in figure 13-1, provides an accurate reference junction for thermocouple measurements.

The TRC accepts input voltages from up to 15 thermocouples, generates a reference voltage in proportion to the temperature of the TRC, and transfers the thermocouple voltages and the reference voltage to its output connectors. (The HP 2250 can convert these measurements directly into temperature readings. Refer to the HP 2250 Programmer's Manual, part number 25580-90001, for details.)

The HP 25594 TRC is available in two versions:

HP 25594A TRC, for use with the HP 25503 LLMUX card

HP 25594B TRC, for use with the HP 25504 RLYMUX card

WARNING

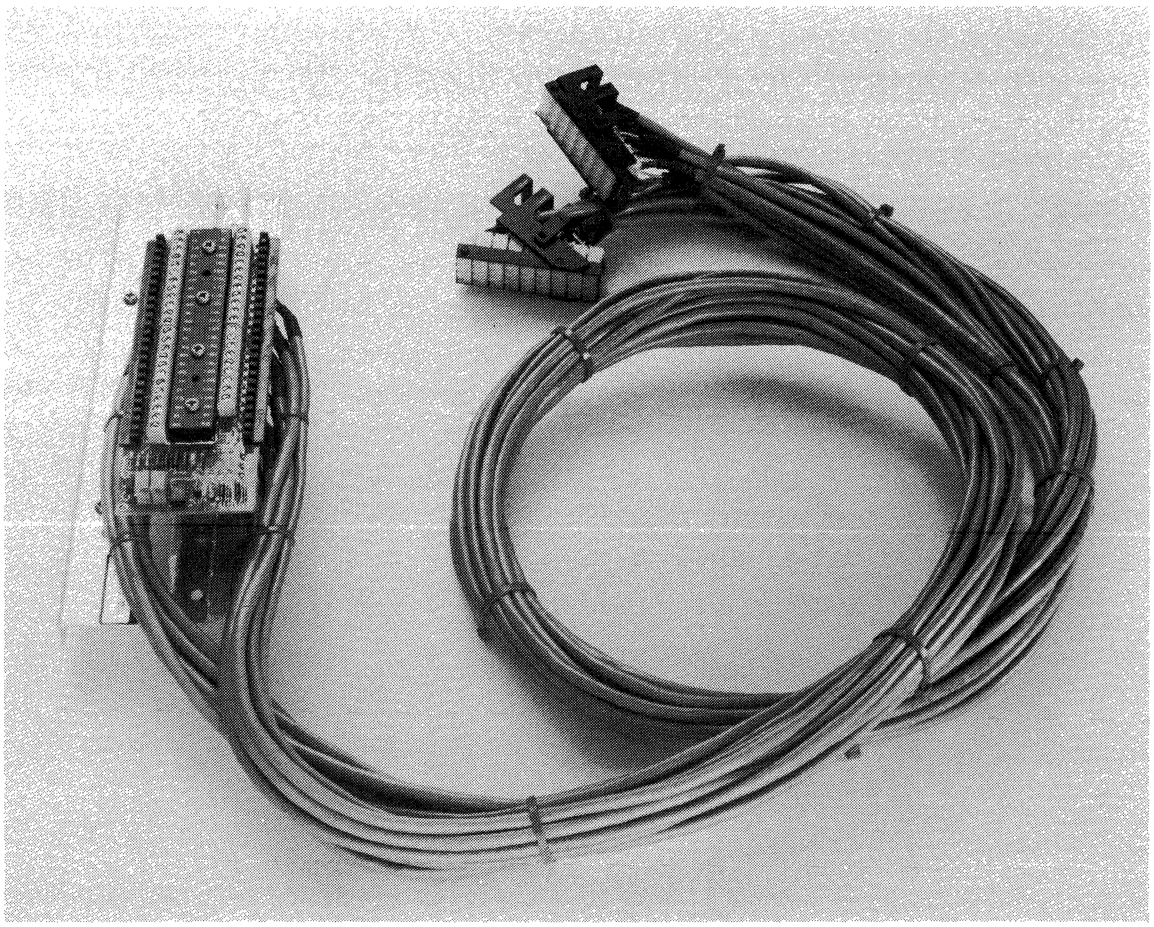
CAUTION

DO NOT CONNECT AN HP 25594A TRC TO AN HP 25504 RLYMUX CARD. Due to differences in the cable configurations of the two TRCs, use of an HP 25594A TRC with a RLYMUX card could result in the routing of high common mode voltages to terminations on the TRC where they are not expected. These common mode voltages may be as high as 350 volts or more, and are potentially lethal. Use only the HP 25594B TRC with the RLYMUX card.

Note that these two TRCs are NOT INTERCHANGEABLE, due to the differences in the cable configurations. As indicated in the warning above, use of an HP 25594A TRC with a RLYMUX card could subject you to hazardous, or even lethal, voltages. Use of the HP 25594B TRC with an LLMUX card is not hazardous, but it will cause you to lose the use of every other channel on the card.

13.3 SPECIFICATIONS

Specifications for the TRC are provided in table 13-1.



52A-0645

Figure 13-1. HP 25594 Thermocouple Reference Connector
(The HP 25594A is shown here. The HP 25594B is similar, except that it has four card connectors instead of two.)

Table 13-1. HP 25594 Specifications

FEATURES	
Up to 15 thermocouple inputs	
Used with types B, E, J, K, R, S, and T thermocouples	
Allows any combination of thermocouple types	
Accepts up to AWG 18 wire	
Provides voltage output proportional to connector temperature	
APPLICATIONS	
Provides an accurate reference junction for thermocouple measurements.	
PROGRAMMING INFORMATION	
REF command:	Read temperature of the specified reference connector
JTEMP command:	Read temperature of the specified type J thermocouple
KTEMP command:	Read temperature of the specified type K thermocouple
TTEMP command:	Read temperature of the specified type T thermocouple
ETEMP command:	Read temperature of the specified type E thermocouple
RTEMP command:	Read temperature of the specified type R thermocouple
STEMP command:	Read temperature of the specified type S thermocouple
BTEMP command:	Read temperature of the specified type B thermocouple

Table 13-1. HP 25594 Specifications (Continued)

ELECTRICAL CHARACTERISTICS	
Temperature Gradient:	< 0.1 degree C (across the entire connector)
Reference Output:	10 mV/degree C nominal
Accuracy (0 to 70 degrees C): (0 to 50 degrees C):	+/- 0.35 degree C +/- 0.25 degree C
Stability:	< 0.3 degree C/1000 hours
Overvoltage Protection:	+/- 80 VDC indefinite (power inputs) +/- 36 VDC indefinite (reference output)
PHYSICAL CHARACTERISTICS	
Width: 5.72 cm (2.25 inches)	
Depth: 16.2 cm (6.4 inches)	
Weight: 300 gm (0.66 pound)	

13.4 FUNCTIONAL DESCRIPTION

Figure 13-2 contains a functional block diagram showing the inputs/outputs and functions of the HP 25594.

The TRC has 15 input channels and 16 output channels. Input channels 1 through 15 receive independent thermocouple voltages from any type of thermocouple. Output channels 1 through 15 are used for transferring the thermocouple voltages to the inputs of the LLMUX or RELMUX. Output channel 16 transfers the thermocouple reference voltage to the input of the LLMUX or RELMUX.

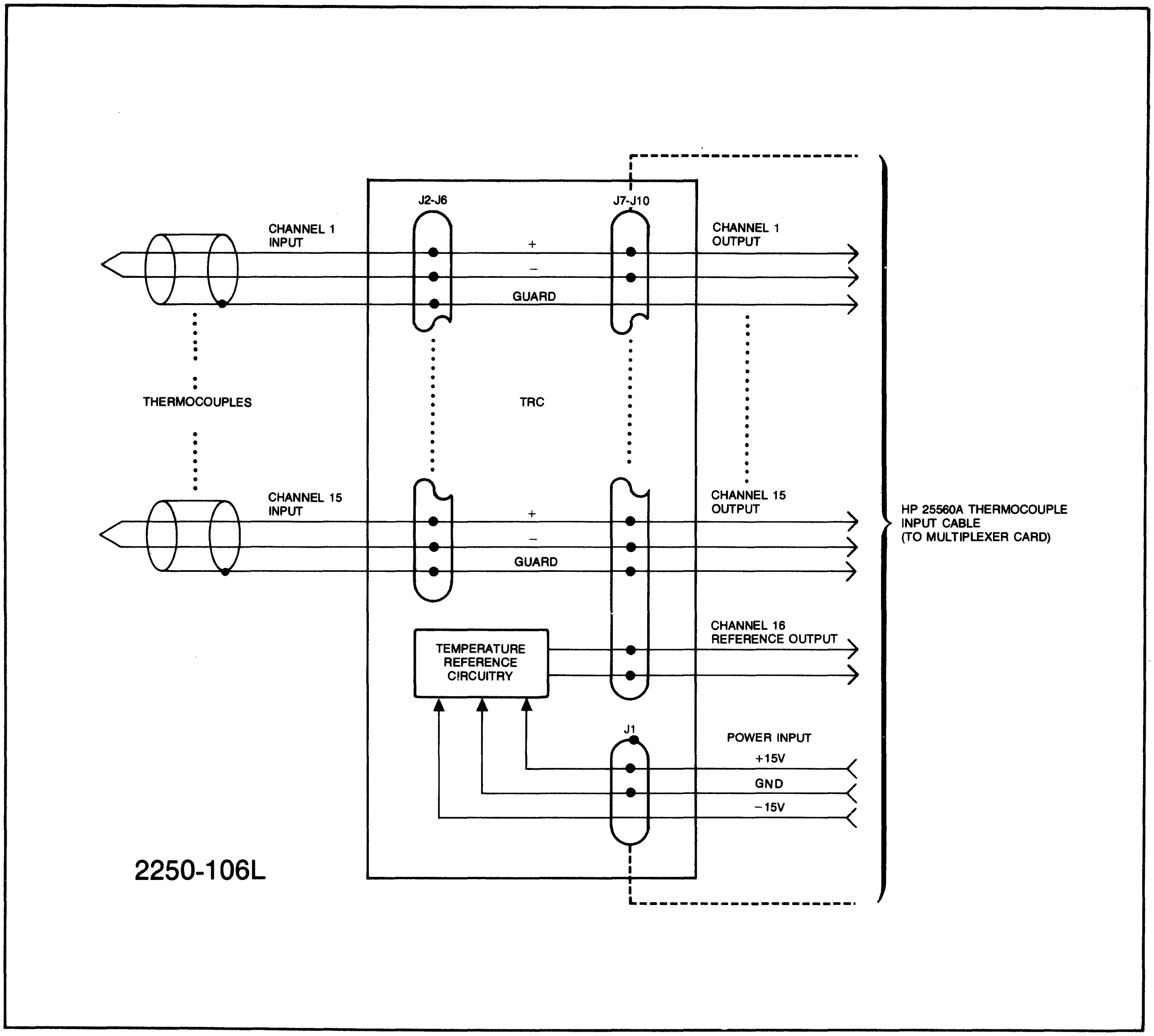


Figure 13-2. HP 25594 Functional Block Diagram

The TRC temperature is converted to a voltage proportional to the TRC temperature and is applied to output channel 16. Power for operating the TRC reference circuitry is supplied by the LLMUX or RELMUX via the Thermocouple Input Cable.

The TRC maintains a uniform temperature across its thermocouple input connectors (thermocouple reference junction points), thereby providing the same temperature for each reference point. If a temperature change does occur, the change will be the same for all thermocouple reference junctions. This allows them to operate with one common reference voltage.

This feature, along with software correction tables, provides accurate TRC operation with inputs from different types of thermocouples (see table 13-1 for the different types of thermocouples).

13.5 CALIBRATION

Calibration of the HP 25594 is performed at the factory under controlled conditions. If re-calibration is necessary, the unit should be returned to Hewlett-Packard.

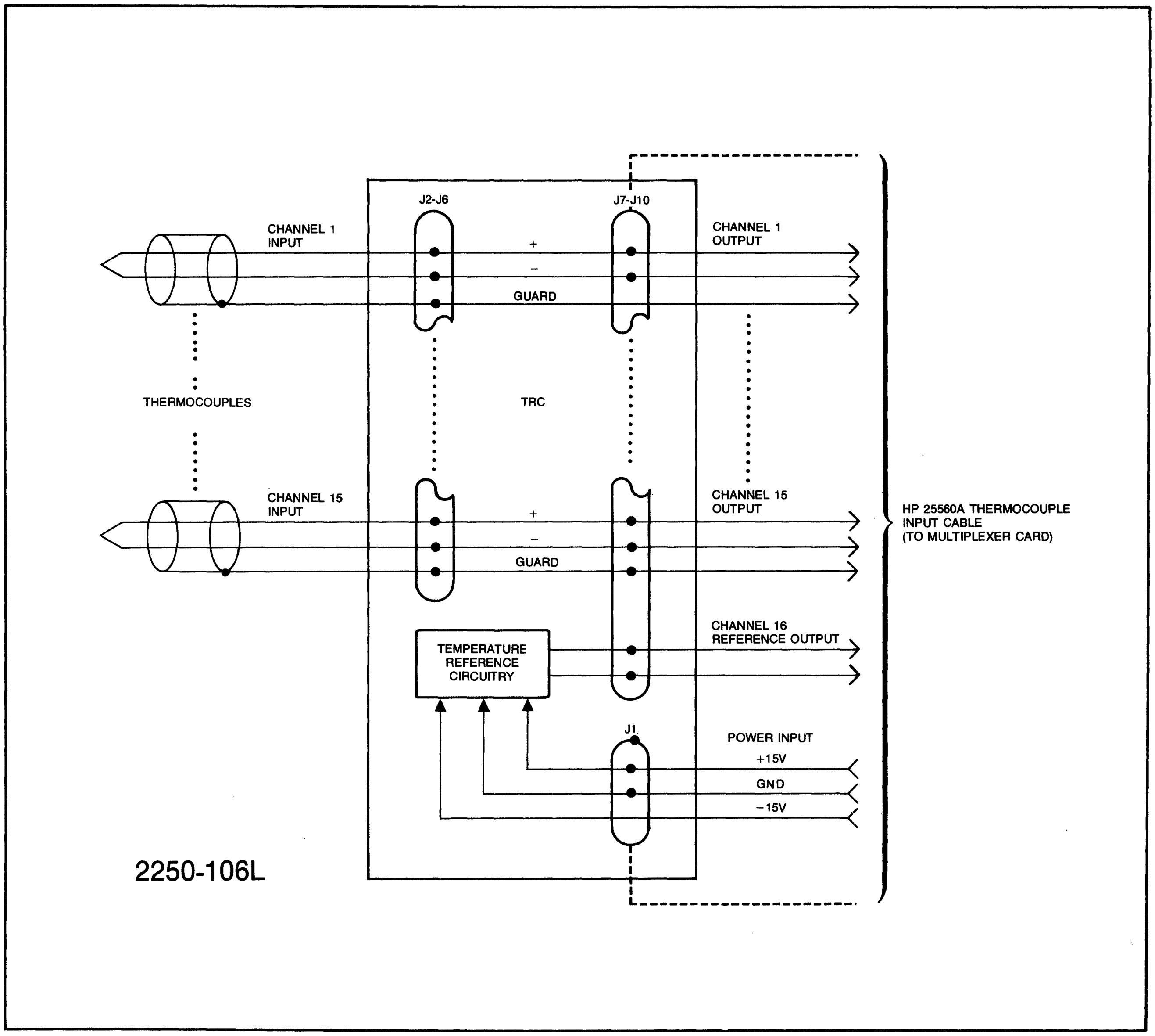


Figure 13-2. HP 25594A Functional Block Diagram

The TRC temperature is converted to a voltage proportional to the TRC temperature and is applied to output channel 16. Power for operating the TRC reference circuitry is supplied by the LLMUX or RELMUX via the Thermocouple Input Cable.

The TRC maintains a uniform temperature across its thermocouple input connectors (thermocouple reference junction points), thereby providing the same temperature for each reference point. If a temperature change does occur, the change will be the same for all thermocouple reference junctions. This allows them to operate with one common reference voltage.

This feature, along with software correction tables, provides accurate TRC operation with inputs from different types of thermocouples (see table 13-1 for the different types of thermocouples).

13.5 CALIBRATION

Calibration of the HP 25594A is performed at the factory under controlled conditions. If re-calibration is necessary, the unit should be returned to Hewlett-Packard.

Section XIV
Signal Conditioning Modules

14.1 INTRODUCTION

This section provides information on the signal conditioning modules (SCMs) available with the HP 2250 Measurement and Control Processor. Included are descriptions and specifications for all SCMs. Installation instructions for the SCMs are provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

14.2 DESCRIPTION

Signal conditioning modules (SCMs) are small printed circuit assemblies that plug onto digital I/O function cards and tailor the cards for interfacing to different types of sensors and actuators. Use of the SCMs gives maximum signal conditioning modularity to the function cards.

SCMs provide input signal conditioning in increments of four points. Because different input SCMs can reside on the same digital input and multifunction cards, a single card can be interfaced to a variety of AC and DC signals. SCMs also provide optional input isolation via optical isolators.

The digital output (HP 25513A) and multifunction (HP 26616A) cards use four point output SCMs to give output switching capability for many types of AC and DC loads. The relay output card (HP 25514A) uses SCMs for relay arc suppression.

All digital function cards can be triggered with an external strobe signal. Therefore, these cards can accept one or two one-point SCMs for interfacing to strobe signals if necessary. Note that the use of the external strobe SCM does not reduce the point capacity of any function card. For example, the HP 25511A 32-Point Digital Input card has all 32 points available regardless of whether the strobe SCM is used or not.

The matrix shown in figure 14-1 indicates which signal conditioning modules may be used with the various digital function cards. Each SCM product number has several alpha suffixes that indicate a specific type of AC or DC signal. For example, the HP 25531 Non-Isolated Digital Input SCM series is available in the following voltage ranges:

HP 25531B	5 VDC range
HP 25531C	12 VDC range
HP 25531D	24 VDC range
HP 25531E	48 VDC range
HP 25531K	5 VDC range, sink inputs
HP 25531L	12 VDC range, sink inputs

Consult the following paragraphs for the individual SCMs for further details.

14.3 SUMMARY OF SIGNAL CONDITIONING MODULES

All SCMs are described in the remainder of this section. A brief summary of the SCMs is presented below:

1-Point/4-Point Non-Isolated Digital Input SCMs:

HP 25531 - 1-Point (Strobe)
HP 25535 - 4-Point

The 1-point/4-point non-isolated digital input SCMs serve as the electrical interface between the function cards and the digital signals in the external process.

1-Point/4-point Isolated Digital Input SCMs:

HP 25533 - 1-Point
HP 25537 - 4-Point

The 1-point/4-point isolated digital input SCMs are used to condition AC/DC signals of various ranges for compatibiltiy with the function cards.

DIGITAL I/O SIGNAL CONDITIONING MODULES (SCMs)

	Strobe SCMs		Input SCMs		Output SCMs			
	25531	**25533**	**25535**	**25537**	**25539**	**25543**	**25544**	**25545**
FUNCTION CARDS	**1 Ch. Non Iso DC**	**1 Ch. Iso AC/DC**	**4 Ch. Non Iso DC**	**4 Ch. Iso AC/DC**	**4 Ch. Relay Arc Suppres**	**4 Ch. Iso DC**	**4 Ch. Non Iso DC**	**2 Ch. AC ***
25511A 32 Point Digital Input Card	√	√	√	√				
25513A 32 Point Digital Output Card	√	√				√	√	√
25514A 16 Point Relay Output Card	√	√			√			
25516A 32 Point Digital Multifunc. Card	√	√	√	√		√	√	√

*Use of all AC output SCMs on the digital output card limits the users to 16 output points.

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Figure 14-1. Signal Conditioning Module Matrix

4-Channel Relay Arc Suppression SCM:

HP 25539

Each 4-channel relay arc suppression SCM provides protection for both the Normally Open (NO) and Normally Closed (NC) contacts of four relays from arcing due to switching inductive loads.

4-Channel Isolated VMOS Output SCM:

HP 25543

The 4-channel isolated VMOS output SCM uses transformer isolation to eliminate ground loops and enable on-card CMOS logic to switch high-level signals.

4-Channel VMOS Output SCM:

HP 25544

The 4-channel VMOS output SCM provide the fastest switching available in the digital output SCM series, with a non-isolated external strobe-to-output switching time of 2 usec.

2-Channel Solid State Relay SCM:

HP 25545

The solid state relay SCM facilitates the switching of AC loads without requiring external wiring.

In addition to the digital function card SCMs described above, an analog input SCM is available, as follows:

8-Channel Analog Input SCM:

HP 25540

The 8-channel analog input SCM provides 250 ohms current loop termination, and 2-pole low pass filters for the HP 25502A and HP 25503A solid state multiplexer cards.

Table 14-0
Signal Conditioning Modules

PRODUCT NO.	DESCRIPTION		PART NO.
25531B	5VDC	One Channel	25531-60001
" C	12VDC	non-isolated	25531-60002
" D	24VDC	digital in	25531-60003
" E	48VDC		25531-60004
" K	5VDC*		25531-60005
" L	12VDC*		25531-60006
25533B	5VDC	One channel	25533-60001
" C	12VDC	non-isolated	25533-60002
" D	24VDC	digital in	25533-60003
" E	48VDC		25533-60004
" F	72VDC		25533-60005
" G	120VDC/72VAC		25533-60006
" H	115VAC		25533-60007
" J	230VAC		25533-60008
25535B	5VDC	Four channel	25535-60001
" C	12VDC	non-isolated	25535-60002
" D	24VDC	digital in	25535-60003
" E	48VDC		25535-60004
" K	5VDC*		25535-60005
" L	12VDC*		25535-60006
25537P	5VDC	Four channel	25537-60001
" Q	12VDC	isolated	25537-60002
" R	24VDC/16VAC	digital in	25537-60003
" S	48VDC		25537-60004
" T	72VDC		25537-60005
" U	120VDC/72VAC		25537-60006
" V	115VAC		25537-60007
" W	230VAC		25537-60008

Table 14-0 (cont.)

PRODUCT NO.	DESCRIPTION		PART NO.
25539A " E " G " H " J	BLANK 0-30 VDC 24VAC 115VAC 230VAC	Four channel relay arc suppression	25539-80001 25539-60005 25539-60007 25539-60008 25539-60009
25540A " B " C " D	BLANK W/FILTER SENS/RES FIL/SEN.RES	Analog In	5081-0106 25540-60001 25540-60002 25540-60003
25543N		Four channel isolated VMOS	25543-60001
25544A " B " C	OPEN DRAIN 5VDC 12VDC	Four channel Non-Isolated VMOS out	25544-60001 25544-60002 25544-60003
25545P		Two channel SSRLY out	25545-60001
N/A	Single channel relay module		25504-60002

* = Sink-type inputs

14.4 SCM USAGE EXAMPLE

An example of how one card can use multiple SCMs is shown below:

HP 25516A 32-Point Digital Multifunction card

INPUTS WITH SCMs	OUTPUTS WITH SCMs
HP 25535B 4-Ch. Non-Iso. 5VDC Input	HP 25543A 4-ch. Iso. VMOS Output
HP 25535D 4-Ch. Non-Iso. 24VDC Input	HP 25544B 4-Ch. 5VDC Output
HP 25537B 4-Ch. Iso. 5VDC Input	HP 25544C 4-Ch. 12VDC Output
HP 25537H 4-Ch. Iso. 115VAC Input	HP 25545A 2-Ch. SSR Output

Strobe SCM: HP 25533D 1-Channel Isolated 24 VDC

14.5 1-POINT/4-POINT NON-ISOLATED DIGITAL INPUT SCMS

The 1-point (HP 25531 Series), and 4-point (HP 25535 Series) SCMs, shown in figure 14-2, are listed below:

HP 25531 1-Point Non-Isolated Digital Input SCM

HP 25531B	5 VDC range
HP 25531C	12 VDC range
HP 25531D	24 VDC range
HP 25531E	48 VDC range
HP 25531K	5 VDC range, sink input
HP 25531L	12 VDC range, sink input

HP 25535 4-Point Non-Isolated Digital Input SCM

HP 25535B	5 VDC range
HP 25535C	12 VDC range
HP 25535D	24 VDC range
HP 25535E	48 VDC range
HP 25535K	5 VDC range, sink inputs
HP 25535L	12 VDC range, sink inputs

14.5.1 HP 25531/25535 Description

A schematic diagram of the HP 25531/25535 SCMs is shown in figure 14-3.

The 1-point/4-point non-isolated digital input SCMs serve as the electrical interface between the digital signals in the external process and the function cards. Hysteresis is provided for increased noise immunity. Debouncing is provided for contact closures and noise filtering. A 1.5 mA wetting current is provided for contact closure sensing.

The 1-point SCM (HP 25531 series) is used for the additional single input (external strobe) found on most digital function cards.

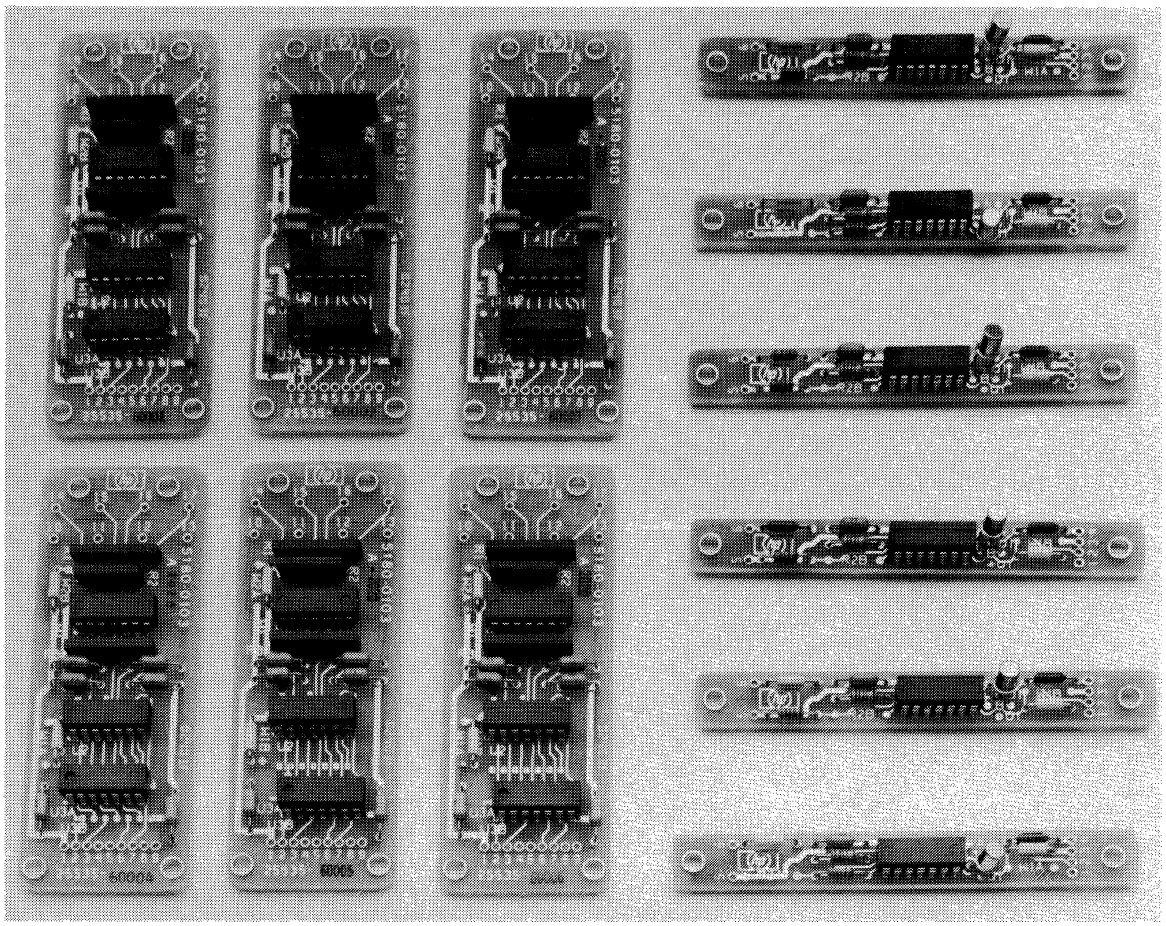

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Figure 14-2. HP 25531/25535 SCMs

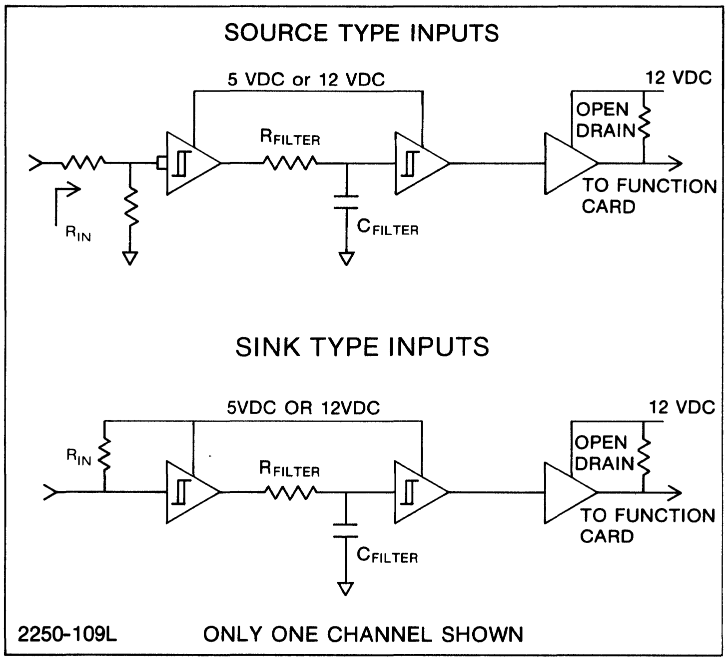

Figure 14-3. HP 25531/25535 Schematic Diagram

14.5.2 HP 25531/25535 Specifications

Specifications for the HP 25531/25535 are provided in table 14-1.

Table 14-1. HP 25531/25535 Specifications

FEATURES

- Hysteresis
- Debounce/noise filter
- Input range/type selection
- Wet sensing of contact closures

APPLICATIONS

- Limit switch sensing
- 5V to 48V voltage sensing
- Relay contact sensing

Static Parameters for Source Type Inputs

Product Number Suffix	Nominal Fullscale Vin (V)	Nominal Fullscale Iin (mA)	Operating Range Vin (V) Min	Operating Range Vin (V) Max	Absolute Maximum Vin (V) Min	Absolute Maximum Vin (V) Max	Rin (K Ω) Min	Rin (K Ω) Max	Turn-off Vin (V) Min	Turn-off Vin (V) Max	Turn-on Vin (V) Min	Turn-on Vin (V) Max
B	5	1.5	–10	15	[illegible]	20	2.9	3.2	0.7	2	3	4.3
C	12	1.5	– 5	15	[illegible]	20	8.0	8.6	1.7	4.8	7.2	10.3
D	24	1.5	– 8	28	[illegible]	38	15.6	17.0	3.3	9.8	14.1	21.1
E	48	1.5	–16	50	[illegible]	51	29.4	30.8	6.0	18.2	25.6	39.1

Static Parameters for Sink Type Inputs

Product Number Suffix	Nominal Open Circuit Vin (V)	Nominal Short Circuit Iin (mA)	Open Circuit Vin (V) Min	Open Circuit Vin (V) Max	Rin (K Ω) Min	Rin (K Ω) Max	Turn-on Vin (V) Min	Turn-on Vin (V) Max	Turn-off Vin (V) Min	Turn-off Vin (V) Max
K	5	–1.5	4.5	[illegible]	2.9	3.2	.7	2	3	4.3
L	12	–1.5	11.5	[illegible]	8.0	8.4	1.7	4.8	7.2	10.3

Table 14-1. HP 25531/25535 Specifications (Continued)

DYNAMIC PARAMETERS (IDENTICAL FOR ALL PRODUCT NUMBERS)

PROPAGATION DELAY

With filter capacitor: 15 msec minimum, 53 msec maximum

Without filter capacitor: 500 nsec minimum, 28 usec maximum

WIDTH OF NARROWEST OUTPUT PULSE

With filter capacitor: 6.9 msec minimum, 49 msec maximum

Without filter capacitor: 200 nsec minimum, 21 usec maximum

NOTES:

1. All products shipped with debounce filter. If no debounce is desired, the filter capacitor must be clipped off.
2. An isolated pulse is one that occurs when the filter capacitor has had time to fully charge or discharge. This time is 100 ms.
3. Due to the pulse stretching effect of the hysteresis, if an input pulse is of sufficient width to be detected, an output pulse of the minimum width will be produced.

14.6 1-POINT/4-POINT ISOLATED DIGITAL INPUT SCMS

The 1-point (HP 25533) and 4-point (HP 25537) isolated digital input SCMs, shown in figure 14-4, are listed below:

HP 25533 1-Point Isolated Digital Input SCM

HP 25533B	5 VDC range
HP 25533C	12 VDC range
HP 25533D	24 VDC (16 VAC) range
HP 25533E	48 VDC range
HP 25533F	72 VDC range
HP 25533G	120 VDC (72 VAC) range
HP 25533H	115 VAC range
HP 25533I	230 VAC range

HP 25537 4-Point Isolated Digital Input SCM

HP 25537P	5 VDC range
HP 25537Q	12 VDC range
HP 25537R	24 VDC (16 VAC) range
HP 25537S	48 VDC range
HP 25537T	72 VDC range
HP 25537U	120 VDC (72 VAC) range
HP 25537V	115 VAC range
HP 25533W	230 VAC range

14.6.1 HP 25533/25537 Description

A schematic diagram of the HP 25533/25537 SCMs is shown in figure 14-5.

The 1-point/4-point isolated digital input SCMs are used to condition AC/DC signals of various ranges for compatibility with the function cards.

The isolation is optical, with threshold sensing performed prior to the LED to obtain independence from LED degradation.

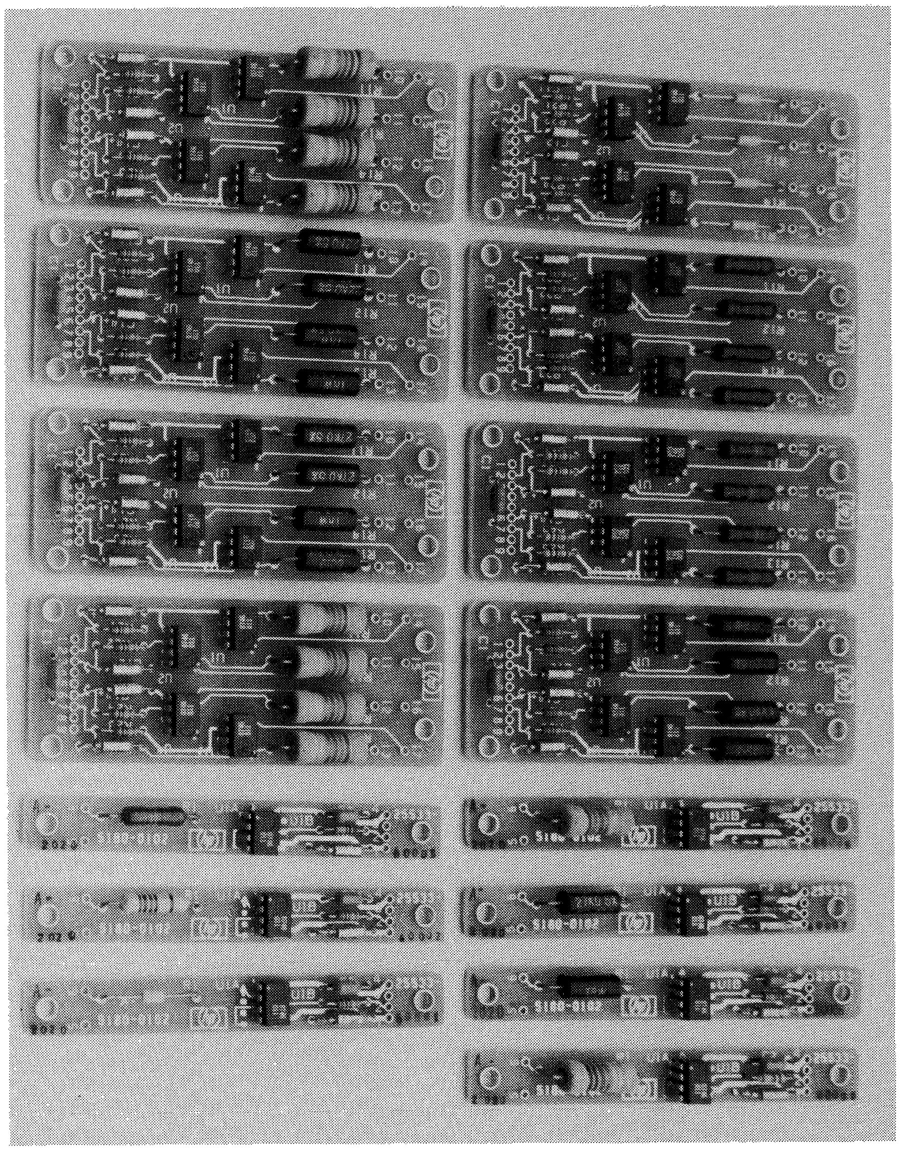

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Figure 14-4. HP 25533/25537 SCMs

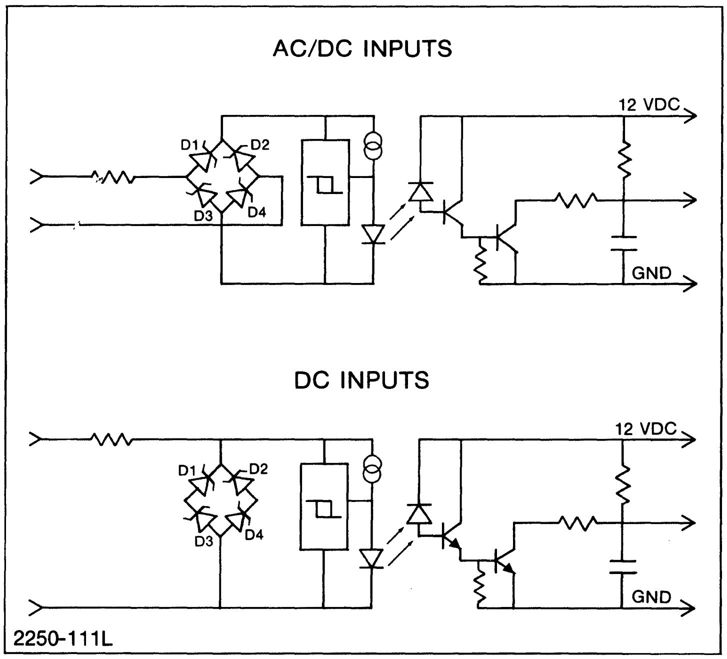

Figure 14-5. HP 25533/25537 Schematic Diagram

14.6.2 HP 25533/25537 Specifications

Specifications for the HP 25533/25537 are provided in table 14-2.

Table 14-2. HP 25533/25537 Specifications

FEATURES Hysteresis Debounce/noise filter Input range selection Optical isolation with thresholds independent of LED degradation AC/DC inputs
APPLICATIONS Limit switch sensing 5 VDC to 230 VAC voltage sensing Relay contact sensing Relay coil voltage monitoring Current sensing

Table 14-2. HP 25533/25537 Specifications (Continued)

STATIC PARAMETERS

Product Number Suffix	Nominal Fullscale (V) DC/AC	Nominal Input Power Dissipation (mW)	Maximum Operating Vin and Resultant Lin		DC Input Thresholds				AC Input Threshold (VAC)	
			Vin (V) DC/AC	• Lin (mA) DC/AC	Turn-Off (VDC)		Turn-On (VDC)			
					Min	Max	Min	Max	Min	Max
B,P	5/ –	25/ –	10/ –	15/ –	2.0	2.9	3.4	4.1	—	—
C,P	12/ –	60/ –	18/ –	15/ –	3.2	4.8	5.7	7.9	—	—
D,R	24/16	120/80	30/30	10/10	6.3	9.9	11.0	16.4	7.8	11.6
E,S	48/ –	240/ –	77/77	10/10	10.7	18.2	19.5	32.3	13.8	22.8
F,T	72/ –	360/ –	100/100	10/10	14.3	24.7	26.6	44.7	18.8	31.6
G,U	120/72	600/360	140/140	8/8	23.8	41.7	45.2	77.3	32.0	54.7
H,V	–/115	–/575	160/160	7/7	28.5	50.2	54.5	93.7	38.5	66.2
J,W	–/230	–/1150	250/250	5/5	56.1	99.5	108.4	188.4	76.7	133.2

NOTES:

1. Due to the pulse stretching effect of the hysteresis, if an input pulse has enough energy to be detected (i.e., if the capacitor is allowed to charge/discharge sufficiently to cross one threshold), an output pulse of width as indicated above will be produced (i.e., of width equal to the time that it takes the capacitor to discharge/charge sufficiently to cross the other threshold).

2. In order for an input pulse to be detected, it must be wider than the maximum propagation delay. (Input pulses of width less that the minimum progagation delay will be ignored.)

3. A "TURNED OFF" input produces a high output voltage which is interpreted by the function cards as a logic zero.

   A "TURNED ON" input produces a low output voltage which is interpreted by the function cards as a logic one. Note that undriven inputs produce logic zeros.

4. The SCM load consists of a 56K resistor to +12 V on the function card.

Table 14-2. HP 25533/25537 Specifications (Continued)

5. Positive current flows into the SCM input.

6. AC voltages and currents are RMS.

7. All products shipped with debounce filter. If no debounce is desired, the filter capacitor must be clipped off. The filter is required for AC operation.

INPUT CURRENT AT NOMINAL INPUT VOLTAGE

5 mA

INPUT TURN-ON CURRENT

1.96 mA minimum, 3.11 mA maximum

INPUT TURN-OFF CURRENT

1.00 mA minimum, 1.62 mA maximum

INPUT-OUTPUT INSULATION LEAKAGE CURRENT

Maximum 1 uA at 25 degrees/C, 45% relative humidity, and Vin-out = 2500 VDC applied for 5 seconds

DYNAMIC PARAMETERS

PROPAGATION DELAY TIME TO LOGIC LOW OUTPUT LEVEL

With filter capacitor: 400 usec minimum, 1.4 msec maximum

Without filter capacitor: 20 usec maximum

PROPAGATION DELAY TIME TO LOGIC HIGH OUTPUT LEVEL

With filter capacitor: 40 msec minimum, 133 msec maximum

Without filter capacitor: 70 usec maximum

Table 14-2. HP 25533/25537 Specifications (Continued

WIDTH OF NARROWEST LOW-GOING OUTPUT PULSE
With filter capacitor: 18 msec minimum, 123 msec maximum
WIDTH OF NARROWEST HIGH-GOING OUTPUT PULSE
With filter capacitor: 18 usec minimum, 1.3 msec maximum
AC INPUT FREQUENCY RANGE:
With filter capacitor: 47 Hz minimum, 420 Hz maximum

14.7 4-CHANNEL RELAY ARC SUPPRESSION SCMS

The HP 25539 4-channel relay arc suppression SCMs, shown in figure 14-6, are listed below:

HP 25539A	For user-suppled components
HP 25539E	0 to 30 VDC arc suppression
HP 25539G	24 VAC arc suppression
HP 25539H	115 VAC arc suppression
HP 25539J	230 VAC arc suppression

14.7.1 HP 25539 Description

A schematic diagram of the HP 25539 SCM is shown in figure 14-7.

Each SCM provides protection for both the normally open and normally closed contacts of four relays from arcing due to switching inductive loads.

14.7.2 HP 25539 Specifications

Specifications for the HP 25539 are provided in table 14-3.

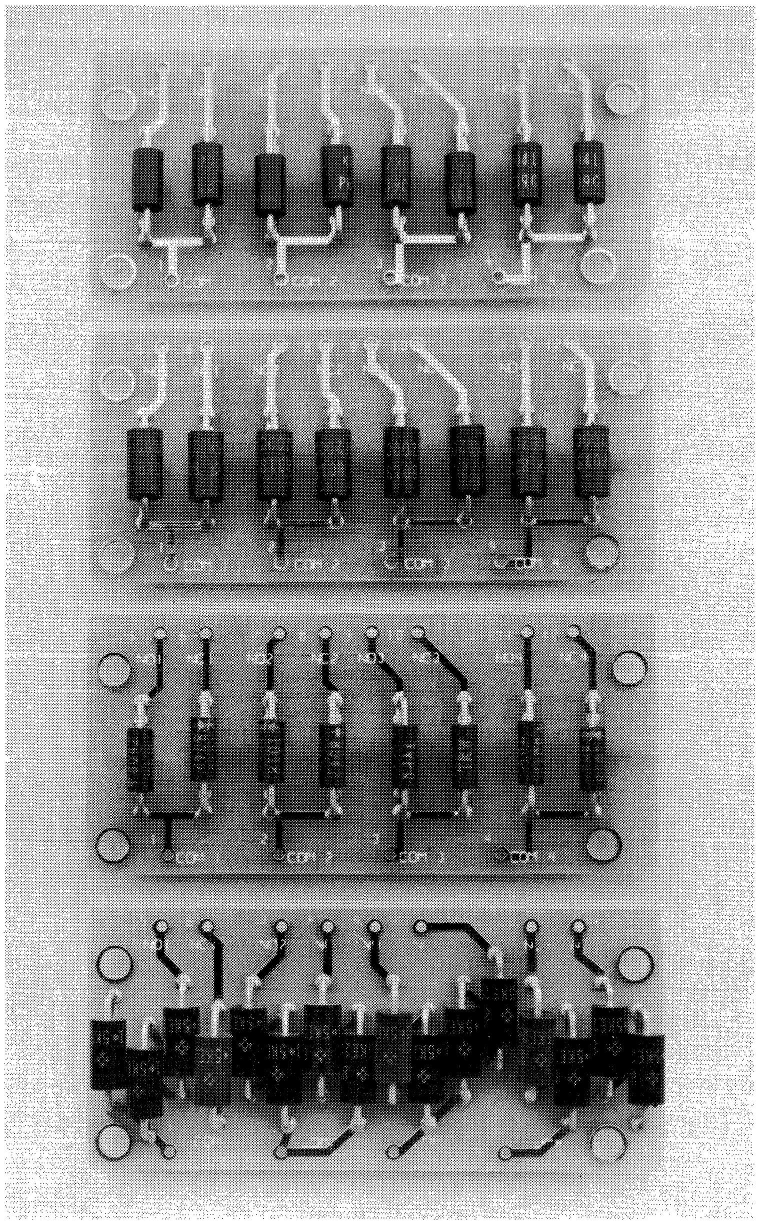

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Figure 14-6. HP 25539 SCMs

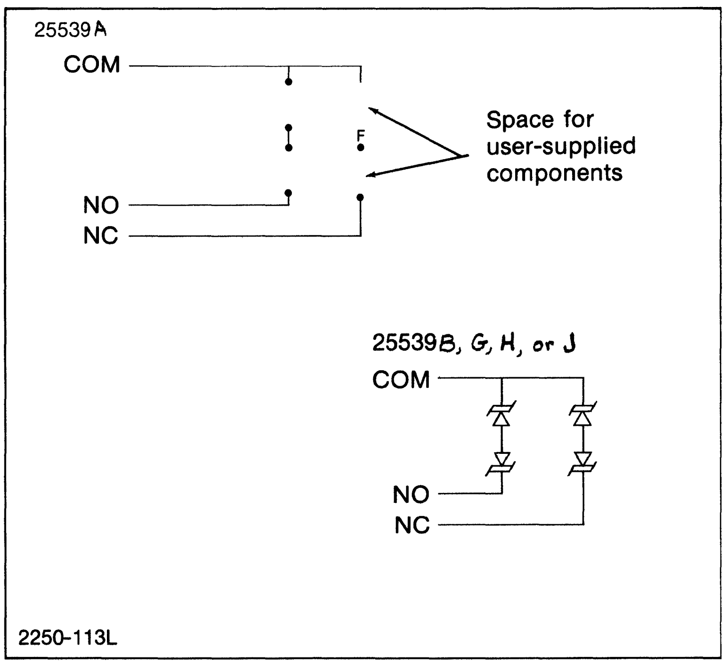

Figure 14-7. HP 25539 Schematic Diagram

Table 14-3. HP 25539 Specifications

FEATURES

Transient suppression for both the normally open and normally closed contacts of four relays.

Suitable for 0 - 30 VDC loads, or 24 - 230 VAC loads.

HP 25539A provides space for user-supplied arc suppression components such as R-C snubber networks.

HP 25539B provides high-speed bipolar transient suppression for 0 - 30 VDC load.

HP 25539G, H, and J provide high-speed bipolar transient suppression zener diodes for 24 VAC, 115 VAC, and 230 VAC, respectively.

APPLICATIONS

Used to prevent damage and reduce noise due to voltage spikes accompanying the switching of inductive loads.

HP 25539A

The HP 25539A 4-Channel Relay Arc Suppression SCM provides space for two components per relay pole as shown in figure 14-7. Maximum space available for the components is as follows:

	WIDTH	LENGTH	HEIGHT	LEAD DIAMETER	
COMPONENT 1	2.54 mm 0.1 inch	12.7 mm 0.5 inch	12.7 mm 0.5 inch	1.06 mm 0.042 inch	
COMPONENT 2	6.35 mm 0.25 inch	20.3 mm 0.8 inch	12.7 mm 0.5 inch	1.06 mm 0.042 inch	

Table 14-3. HP 25539 Specifications (Continued)

HP 25539B

Maximum clamping time:	5 nsec
Peak current:	3 A
Reverse stand-off voltage:	30 VDC
Maximum clamping voltage:	57 volts
Breakdown voltage:	35 - 43 volts
Maximum reverse leakage at 30 VDC, 25 degrees C:	5 uA

HP 25539G, H, and J

Maximum clamping time:	5 nsec
Peak current:	3 A

	Reverse Stand-off Voltage	Breakdown Voltage at 1 mA	Maximum Clamping Voltage at 3 A	Maximum Reverse Leakage at 25 degrees C	
25539	V (Vrms)	V	V	uA	
G	24 V	39 - 47	50	5	
H	115 V	180 - 220	260	5	
J	230 V	360 - 440	528	5	

14.8 8-CHANNEL ANALOG INPUT SCMS

The HP 25540 8-channel analog input SCMs, shown in figure 14-8, are listed below:

HP 25540A	For user-supplied components
HP 25540B	Psssive filter network capacitors
HP 25540C	Passive filter network current-loop resistors
HP 25540D	Passive filter network current-loop resistors and filter capacitors

14.8.1 HP 25540 Description

A schematic diagram of the HP 25540 SCM is shown in figure 14-9.

The HP 25540 SCMs provide 250 ohms current loop termination, and two-pole low-pass filters for the HP 25502A 32-Channel High-Level Multiplexer and the HP 25503A 32-Channel Low-Level Multiplexer cards. These SCMs also allow space for users to mount their own current termination resistors and filter capacitors.

14.8.2 HP 25540 Specifications

Specifications for the HP 25540 are provided in table 14-4.

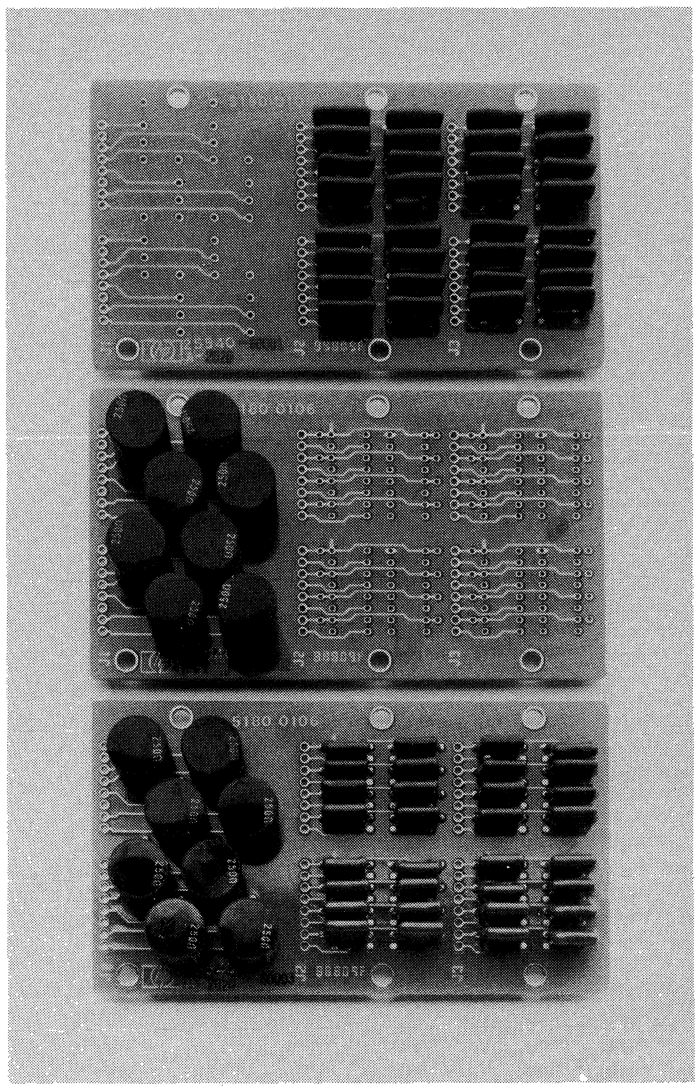

Figure 14-8. HP 25540 SCMs

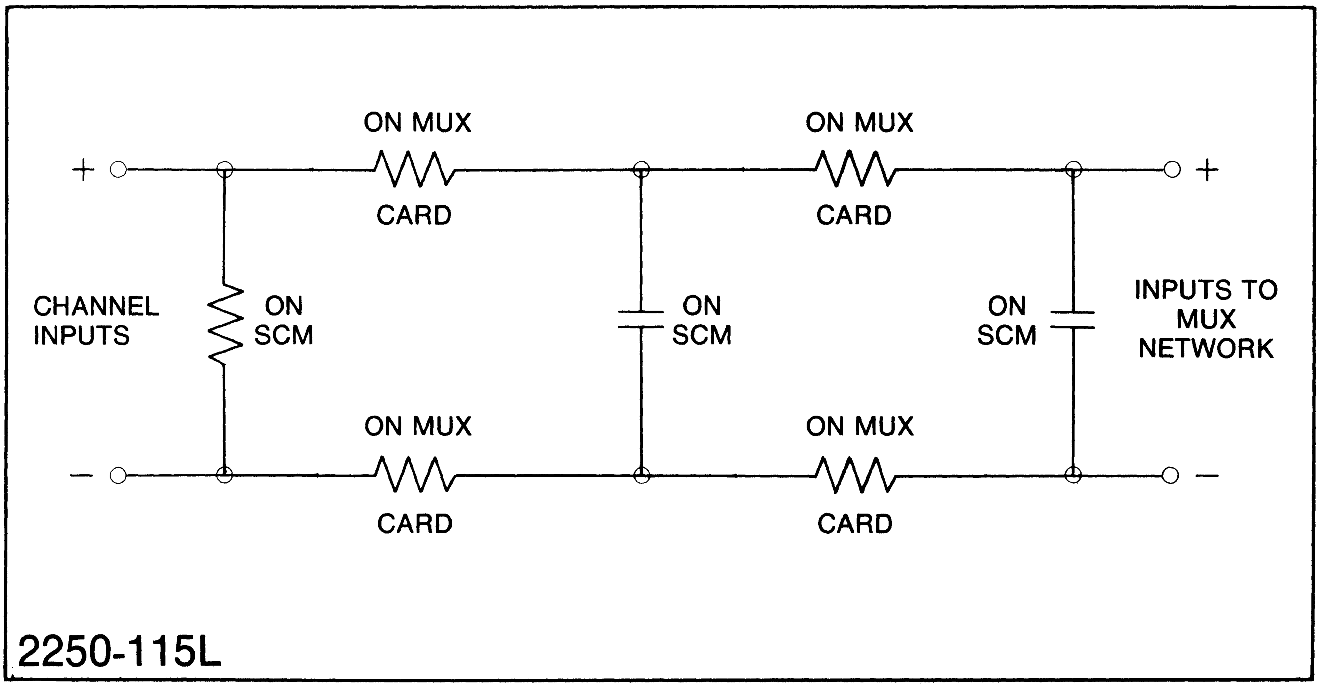

Figure 14-9. HP 25540 Schematic Diagram

Table 14-4. HP 25540 Specifications

FEATURES

250-ohm termination resistors

Two-pole RC filters

Space for user-selected termination

Space for user-selected filter capacitors

APPLICATIONS

Used for current loop termination and/or input filtering.

ELECTRICAL CHARACTERISTICS

Current loop termination:

Resistance:	250 ohm +/- 0.025%
Temperature coefficient:	10 PPM/degree C
Filter pole frequencies (minimum):	52 Hz 7.5 Hz

Filters:

PRODUCT NUMBER	FILTERS	CURRENT TERMINATION	
HP 25540A	*	*	
HP 25540B	YES	*	
HP 25540C	*	YES	
HP 25540D	YES	YES	

* Space available for user-supplied components

14.9 4-CHANNEL ISOLATED VMOS OUTPUT SCM

The HP 25543A 4-Channel Isolated VMOS SCM is shown in figure 14-10.

14.9.1 HP 25543A Description

A schematic diagram of the HP 25543A is shown in figure 14-11.

The HP 25543A uses transformer isolation to eliminate ground loops and enable on-card CMOS logic to switch high-level signals. Each HP 25543A contains four fully isolated channels, each of which can operate at frequencies up to 30 KHz.

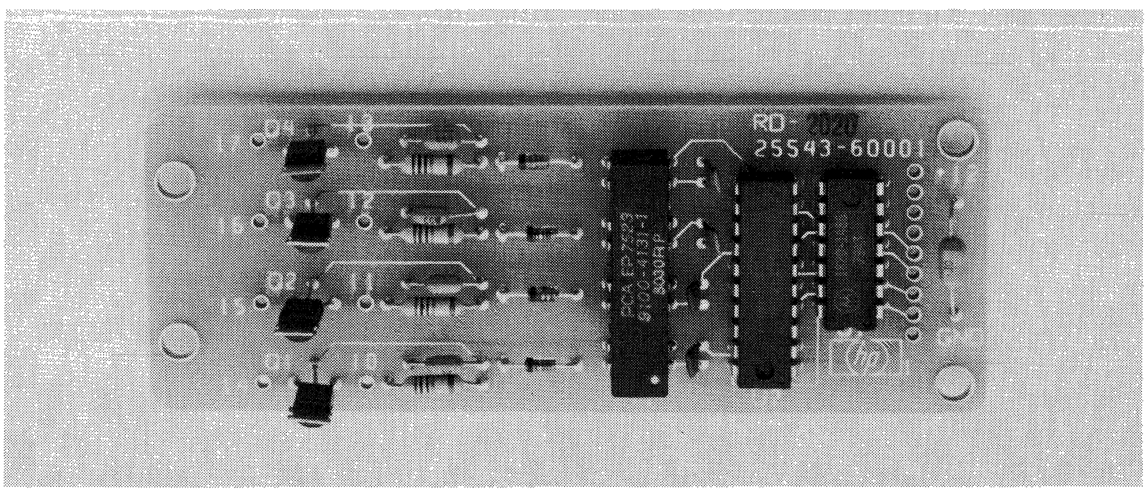

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Figure 14-10. HP 25543A SCM

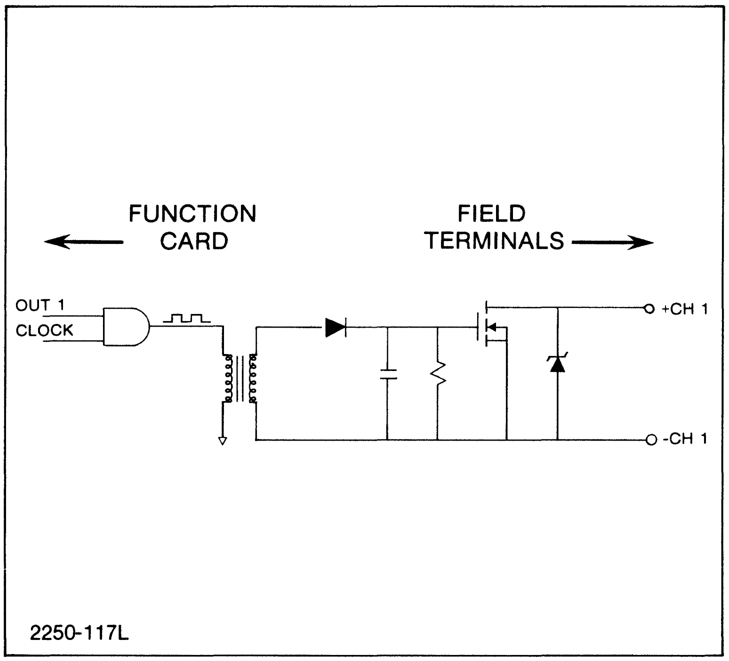

Figure 14-11. HP 25543A Schematic Diagram

14.9.2 HP 25543A Specifications

Specifications for the HP 25543A are provided in table 14-5.

Table 14-5. HP 25543A Specifications

FEATURES	
Four independent channels per card	
Can be used with pulse, multifunction, and digital output function cards	
Pulse transformer isolation to 1500 volts	
APPLICATIONS	
Isolation allows switching of high common mode voltages	
VMOS field effect transistors switch 60 VDC, 300 mA	
AC signals up to 42 VAC rms, 300 mA can be switched by configuring channels back-to-back	
Controls motor contacting relays and actuating solenoids	
ELECTRICAL CHARACTERISTICS	
Output Voltage:	60 volts, maximum
Output Sink Current: (logic 1 (mA) at V = 0.75V	300 volts, maximum
Rise Time:	50 nsec, typical
Fall Time:	200 nsec, typical
Turn-On Delay:	2 usec, maximum
Turn-Off Delay:	30 usec, maximum
Isolation, input to output:	1500 volts, minimum
Off-State Leak Current:	10 uA, maximum

14.10 4-CHANNEL NON-ISOLATED VMOS OUTPUT SCM

The HP 25544 4-Channel Non-Isolated VMOS Output SCMs, shown in figure 14-12, are listed below:

HP 25544A	Open drain circuit
HP 25544B	5 VDC range
HP 25544C	12 VDC range

14.10.1 HP 25544 Description

A schematic diagram of the HP 25544 is shown in figure 14-13.

The HP 25544 series SCMs are driven directly from CMOS logic levels on the digital function cards. The SCMs provide the fastest switching available in the digital output SCM series, with a non-isolated external strobe-to-output switching time of 2 usec.

The HP 25544A SCM is an open-drain transistor with zener overvoltage protection. This SCM will switch 42 VAC, rms loads across +CH1 and +CH2 (when -CH1 and -CH2 are left open), and across +CH3 and +CH4 (when -CH3 and -CH4 are left open).

The HP 25544B and HP 25544C SCMs use pull-up resistors connected to on-card voltage regulators to drive +5 and +12 volt logic.

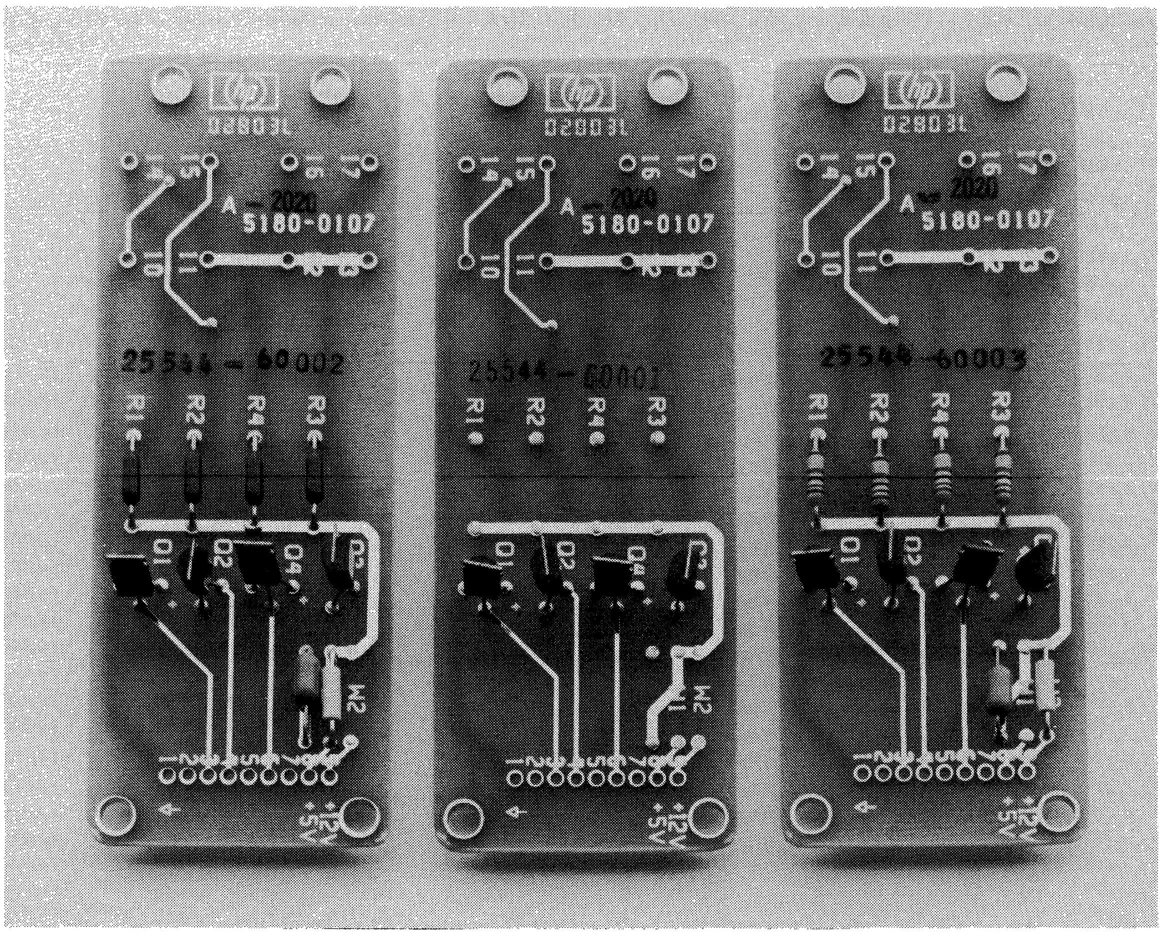

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Figure 14-12. HP 25544 SCMs

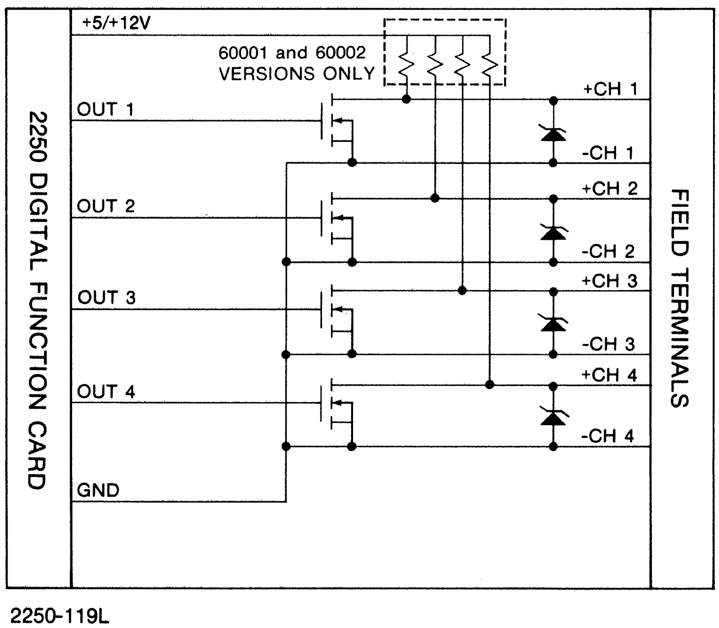

Figure 14-13. HP 25544 Schematic Diagram

14.10.2 HP 25544 Specifications

Specifications for the HP 25544 are provided in table 14-6.

Table 14-6. HP 25544 Specifications

FEATURES	
Four independent channels per card	
Can be used with digital output, multifunction, and pulse output function cards.	
High-speed switching provided through VMOS field effect transistors	
Outputs are disabled (turned off) at power-on and power-off	
APPLICATIONS	
The HP 25544A is used to provide switching of DC signals up to 60 volts, 300 mA.	
The HP 25544B is used to drive TTL logic.	
The HP 25544C is used to drive MOS/CMOS +12 volt logic.	
ELECTRICAL CHARACTERISTICS	
HP 25544A	
Maximum Logic 0 Output Voltage:	60 VDC, 42 VAC, rms
Maximum Continuous Output:	300 mA sink
Maximum Logic 1 Output Voltage:	750 mV at 300 mA sink 250 mV at 100 mA sink
Full-Voltage Output Waveshapes:	Rise and Fall Times 20 nsec typical (resistive load)

Table 14-6. HP 25544 Specifications (Continued)

Turn-On/Turn-Off Delays:	10 nsec maximum					
HP 25544B and HP 25544C	HP 25544B			HP 25544C		
	MIN	TYP	MAX	MIN	TYP	MAX
Internal Pull-Up Voltage (V)	4.8	5	5.2	11.5	12	12.5
Output Source Current (mA)	2.1	2.3		5.2	5.6	
Output Sink Current (mA)			300			300
Logic 1 Output Voltage (V) Isink = 300 mA Isink = 100 mA			 0.75 0.25			 0.75 0.25
Output Rise, Fall Times (ns)			5			5
Turn On, Turn Off Delays (ns)			5			5
Pull-Up Resistance		2.15			2.15	

14.11 2-CHANNEL SOLID STATE RELAY OUTPUT SCM

The HP 25545P 2-Channel Solid State Relay Output SCM is shown in figure 14-14.

14.11.1 HP 25545P DESCRIPTION

A schematic diagram of the HP 25545P is shown in figure 14-15.

The HP 25545P facilitates the switching of AC loads without requiring external wiring. The HP 25545P fits onto any DC SCM location, and the AC output points are between:

1. The + side of the first channel (+CH1) and the - side of the second channel (-CH2)

2. The + side of the third channel (+CH3) and the - side of the fourth channel (-CH4)

of each SCM.

Each channel will switch up to 120 VAC, 800 mA at 55 degrees C. Optical isolation eliminates ground loops and keeps high voltages away from the logic components of the mother card. Zero voltage turn-on makes the solid state relay outputs ideal for switching filament lamp loads, and RC snubber networks enable inductive load switching to power factors of 0.50 or more.

14.11.2 HP 25545P SPECIFICATIONS

Specifications of the HP 25545P are provided in table 14-7.

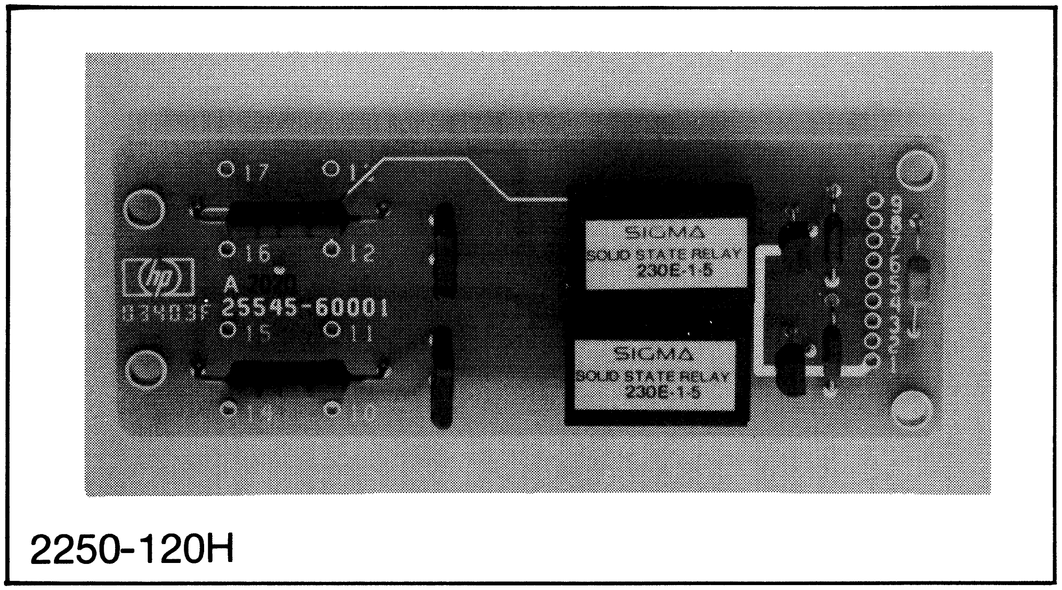

Figure 14-14. HP 25545P SCM

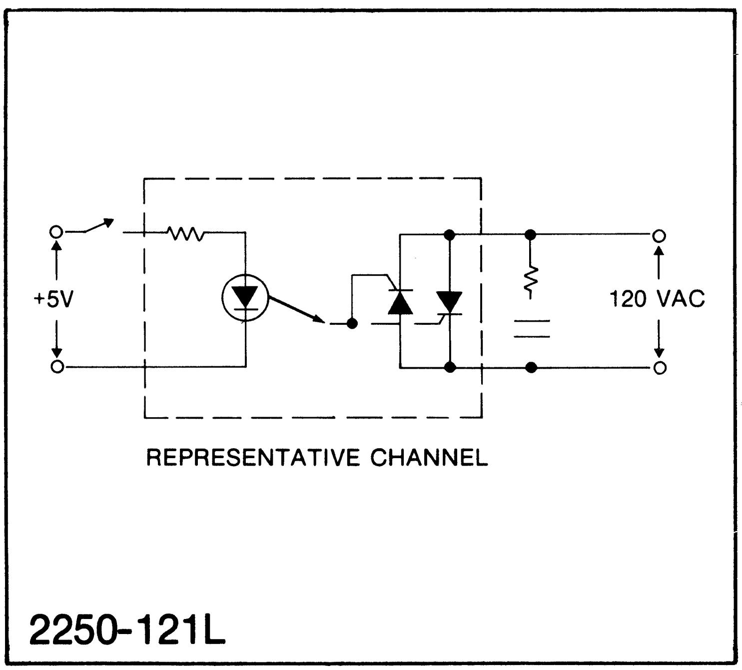

Figure 14-15. HP 25545P Schematic Diagram

Table 14-7. HP 25545P Specifications

FEATURES

Zero voltage turn-on reduces EMI, RFI

Optical isolation to 2500 volts

Can be used with the digital output, multifunction, and pulse function cards

Snubber networks ensure low power factor turn-on

APPLICATIONS

120 VAC switching to 180 watts (at 25 degrees C to 40 degrees C) or 90 watts (at 70 degrees C)

Used to interface to motors, lamps, and transformers

ELECTRICAL CHARACTERISTICS

RMS On-State Voltage:	1.5 volts maximum
RMS On-State Current:	0.8 amps maximum
Holding Current:	3 mA maximum
Off-State rms Current	
With Snubber:	3 mA maximum
Without Snubber:	1 mA maximum
Turn-On/Turn-Off Time:	1/2 cycle maximum
Operating Frequency:	30 Hz minimum 400 Hz maximum
Isolation, Input to Output:	2500 VAC, rms minimum
Capacitance, Input to Output:	5 pF maximum

Table 14-7. HP 25545P Specifications (Continued)

Critical Rate of Rise of Off-State Voltage at V = 300 V:	50 V/us minimum
Peak Repetitive Off-State Voltage:	+/- 300 volts maximum
Critical Rate of Rise of On-State Current, dI/dT:	20 A/us maximum
Load Power Factor for Guaranteed Turn-On:	0.50 minimum

14.11 2-CHANNEL SOLID STATE RELAY OUTPUT SCM

The HP 25545A 2-Channel Solid State Relay Output SCM is shown in figure 14-14.

14.11.1 HP 25545A Description

A schematic diagram of the HP 25545A is shown in figure 14-15.

The HP 25545A facilitates the switching of AC loads without requiring external wiring. The HP 25545A filts onto any DC SCM location, and the AC output points are between:

1. The + side of the first channel (+CH1) and
   the - side of the second channel (-CH2)

2. The + side of the third channel (+CH3) and
   the - side of the fourth channel (-CH4)

of each SCM.

Each channel will switch up to 120 VAC, 800 mA at 55 degrees C. Optical isolation eliminates ground loops and keeps high voltages away from the logic components of the mother card. Zero voltage turn-on makes the solid state relay outputs ideal for switching filament lamp loads, and RC snubber networks enable inductive load switching to power factors of 0.30 or more.

14.11.2 HP 25545A Specifications

Specifications of the HP 25545A are provided in table 14-7.

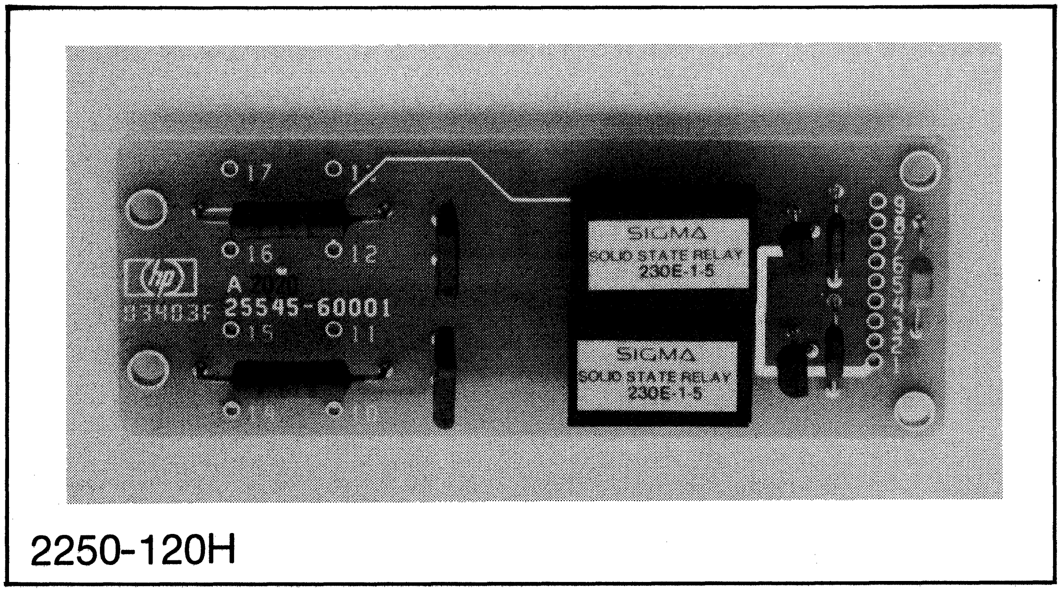

Figure 14-14. HP 25545A SCM

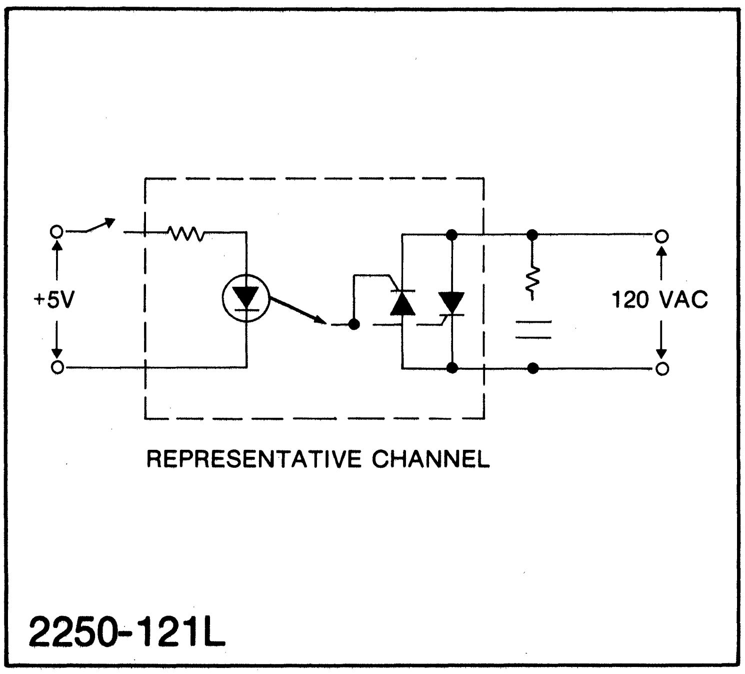

Figure 14-15. HP 25545A Schematic Diagram

Table 14-7. HP 25545A Specifications

FEATURES

Zero voltage turn-on reduces EMI, RFI

Optical isolation to 4000 volts

Can be used with the digital output, multifunction, and pulse function cards

Snubber networks ensure low power factor turn-on

APPLICATIONS

120 VAC switching to 100 watts

Used to interface to motors, lamps, and transformers

ELECTRICAL CHARACTERISTICS

RMS On-State Voltage:	1.5 volts maximum
RMS On-State Current:	0.8 amps maximum
Holding Current:	3 mA maximum
Off-State rms Current	
With Snubber:	3 mA maximum
Without Snubber:	1 mA maximum
Turn-On/Turn-Off Time:	1/2 cycle maximum
Operating Frequency:	30 Hz minimum 400 Hz maximum
Isolation, Input to Output:	2500 VAC, rms minimum
Capacitance, Input to Output:	5 pF maximum

Table 14-7. HP 25545A Specifications (Continued)

Critical Rate of Rise of Off-State Voltage at $V = 300$ V:	50 V/us minimum
Peak Repetitive Off-State Voltage:	+/- 300 volts maximum
Critical Rate of Rise of On-State Current, $\frac{dI}{dT}$:	40 A/us maximum
Load Power Factor for Guaranteed Turn-On:	0.30 minimum

14.12 4-CHANNNEL NON-ISOLATED BUFFERED OUTPUT SCM

The HP 25546 4-Channel Non-Isolated Buffered Output SCM, shown in figure 14-16, is available as:

HP 25546B 5 VDC range

14.12.1 HP 25546 DESCRIPTION

A schematic diagram of the HP 25546 is shown in figure 14-17.

The HP 25546B digital output SCM is driven from CMOS logic levels on the digital function cards. This SCM is designed to minimize transmission line ringing when driving standard HP 25550 digital cables at high speeds. This capability makes the HP 25546B SCM particularly useful for applications that involve directly driving digital logic, as in most pulse card applications.

The HP 25546B SCM uses a 5 volt CMOS buffer, capable of driving two TTL loads over the full temperature range. An inverting buffer is also part of the SCM to keep the number of inversions consistent with other SCMs.

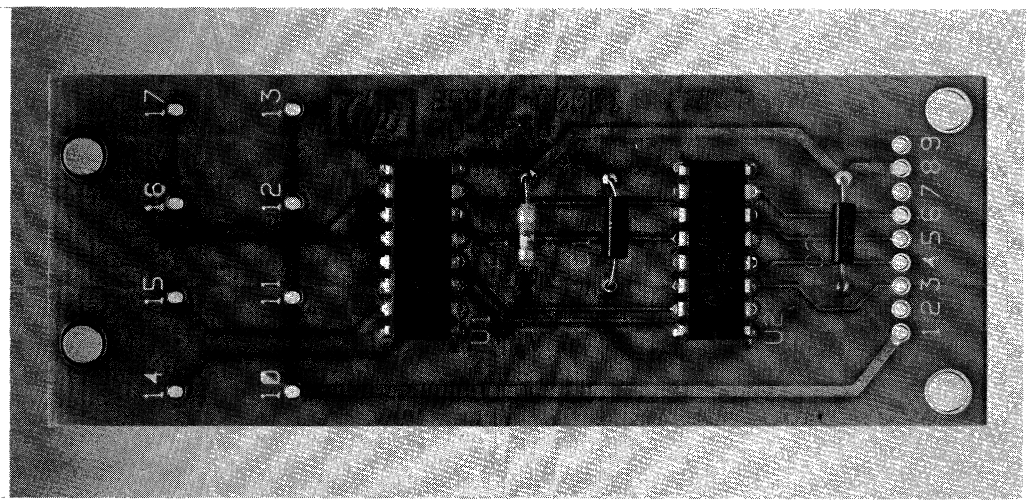

Figure 14-16. HP 25546 SCM

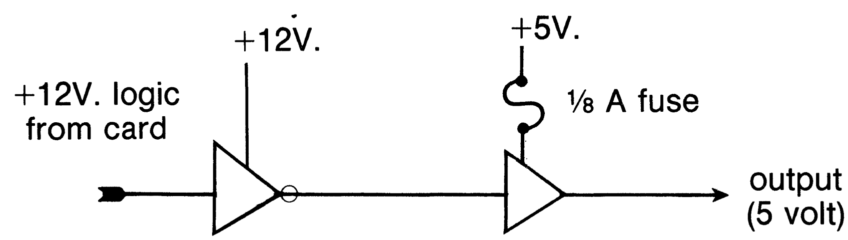

Figure 14-17. HP 25546 Schematic Diagram

14.12.2 HP 25546 SPECIFICATIONS

Specifications for the HP 25546 are provided in table 14-8.

Table 14-8. HP 25546 Specifications

FEATURES

- Four independent channels per card
- Designed especially for pulse card applications
- Designed to minimize transmission line ringing
- Logic 1 at power-on

APPLICATIONS

The HP 25546B is used to drive TTL and 5-volt CMOS logic.

ELECTRICAL CHARACTERISTICS

	HP 25546B			
	MIN	TYP	MAX	UNITS
Logic 1 Output Voltage	4.95			volts
Logic 0 Output Voltage			.05	volts
Low Level Output Current	4.0	5.0		ma
High Level Output Current	-0.9	-1.6		ma
Transition Time (H-L)		30	60	ns
Transition Time (L-H)		60	120	ns
Propagation Delay (H-L)		90	175	ns
Propagation Delay (L-H)		105	205	ns

14.13 4-POINT HIGH SPEED NON-ISOLATED DIGITAL INPUT SCMS

The 4-point (HP 25536 series) SCMs, shown in figure 14-18, are listed below:

HP 25536B	5 VDC range, source inputs
HP 25536K	5 VDC range, sink inputs

14.13.1 HP 25536 DESCRIPTION

A schematic diagram of the HP 25536 SCMs is shown in figure 14-19.

The 4-point high speed non-isolated digital input SCMs serve as the electrical interface between the digital signals in the external process and the HP 25512 counter card. Hysteresis is provided for increased noise immunity. A 1.5 mA wetting current is provided for contact closure sensing.

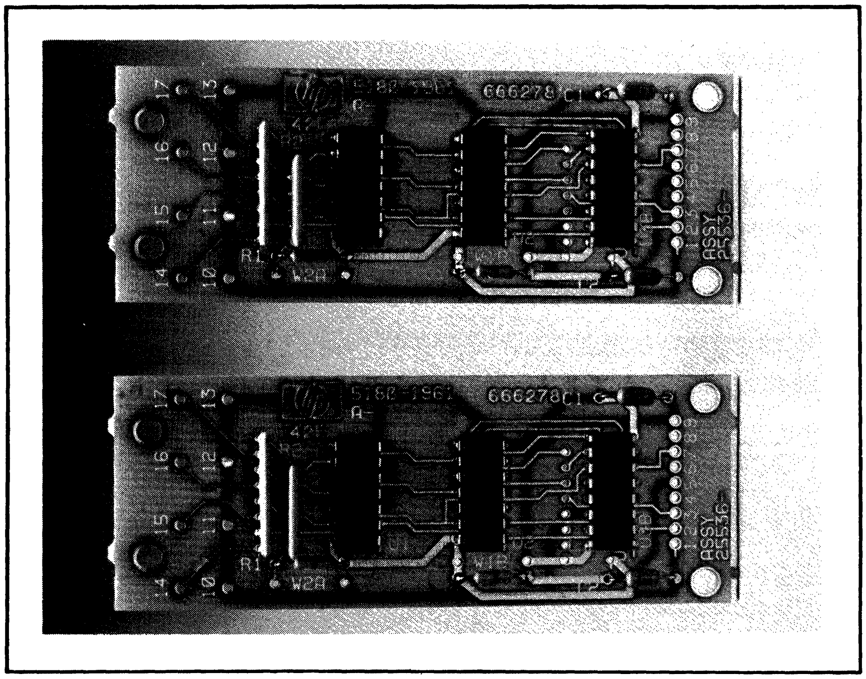

Figure 14-18. HP 25536 SCMs

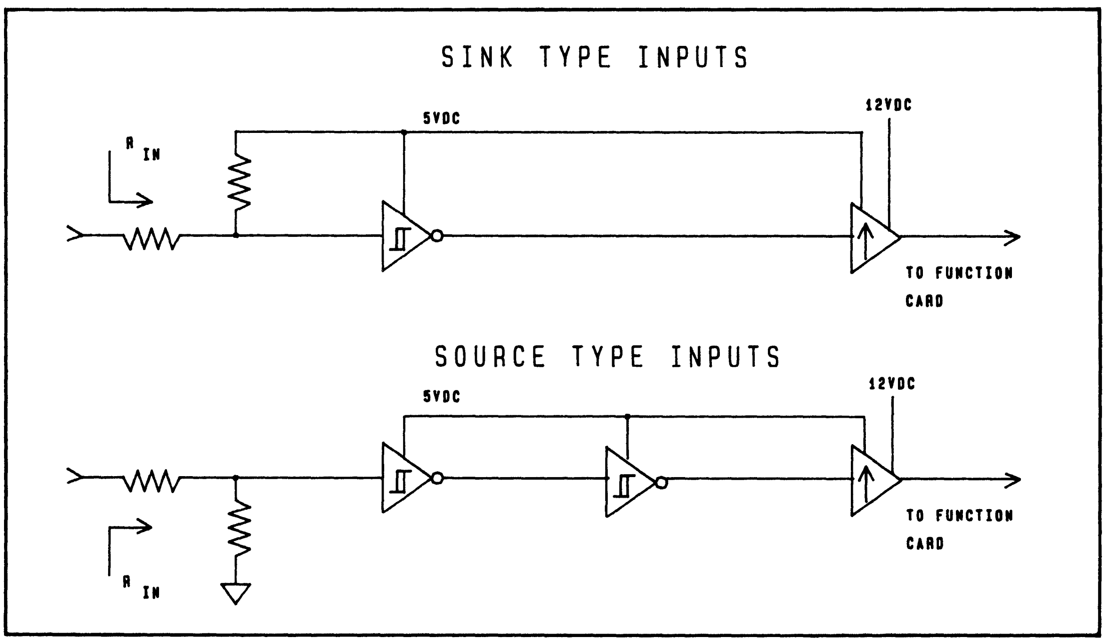

Figure 14-19. HP 25536 Schematic Diagram

14.13.2 HP 25536 SPECIFICATIONS

Specifications for the HP 25536 are provided in table 14-9.

Table 14-9. HP 25536 Specifications

FEATURES

Hysteresis

High speed operation

Source or sink type inputs

APPLICATIONS

TTL-compatible input sensing

STATIC PARAMETERS

Source Type Inputs:

Product Number Suffix	Nominal Fullscale Vin (V)	Nominal Fullscale Iin (mA)	Operating Range Vin (V) Min	Operating Range Vin (V) Max	Absolute Maximum Vin (V) Min	Absolute Maximum Vin (V) Max	Rin (KΩ) Min	Rin (KΩ) Max	Turn-off Vin (V) Min	Turn-off Vin (V) Max	Turn-on Vin (V) Min	Turn-on Vin (V) Max
B	5	1.5	−10	15	−15	20	2.9	3.2	0.7	2	3	4.3

Sink Type Inputs:

Product Number Suffix	Nominal Open Circuit Vin (V)	Nominal Short Circuit Iin (mA)	Open Circuit Vin (V) Min	Open Circuit Vin (V) Max	Rin (KΩ) Min	Rin (KΩ) Max	Turn-on Vin (V) Min	Turn-on Vin (V) Max	Turn-off Vin (V) Min	Turn-off Vin (V) Max
K	5	−1.5	4.5	5.5	2.9	3.2	.7	2	3	4.3

Table 14-9. HP 25536 Specifications (Continued)

DYNAMIC PARAMETERS (IDENTICAL FOR ALL PRODUCT NUMBERS) Propagation delay: t(d) < 1.0 microsecond Rise time: t(r) < 200 nanoseconds Fall time: t(f) < 200 nanoseconds
NOTES: 1. The HP 25536 SCM is intended for use with the HP 25512 counter card in high speed (> 10 kHz) applications. It does not provide debounce or noise filtering (except hysteresis), and therefore should not be used with switch or relay contact type signals. The upper limit of the HP 25536 SCM is 400 kHz.

Section XV
HP 25512 4-Channel Counter Input

15.1 INTRODUCTION

This section provides information for the HP 25512 4-Channel Counter Input Card. Included are specifications and a functional description. Installation information for the card is provided in the HP 2250 Measurement and Control Processor Installation and Start-Up Manual, part number 02250-90012.

15.2 DESCRIPTION

The HP 25512 Counter Card, shown in figure 1-2, is an input function card for the HP 2250 Measurement and Control Processor. It has 4 input channels, each of which can be independently configured for any of 10 counting functions. Each channel has 2 input signals, the A and B inputs: the A input is the primary input and is used for every counting function, while the B input is secondary and is not used by every counting function.

The counter card requires the attachment of two signal conditioning modules (SCMs) to condition the external signals for the A and B inputs. There are two high speed SCMs (HP 25536B, HP 25536K) to support the full speed of the counter card; additionally, any of the HP 25535 or HP 25537 SCMs may be used when the input signals are within their operating range. Each SCM conditions the signals for 2 counter card channels. The maximum input frequency for each of the input signals is 400kHz, and the minimum input pulse width is 1.25 usec.

To support diagnostics, the HP 25512 Counter Card provides 2 TTL level outputs.

There are no other external input or output signals for the counter card.

The counter card has 20 independently enabled interrupt conditions, 5 for each counting channel.

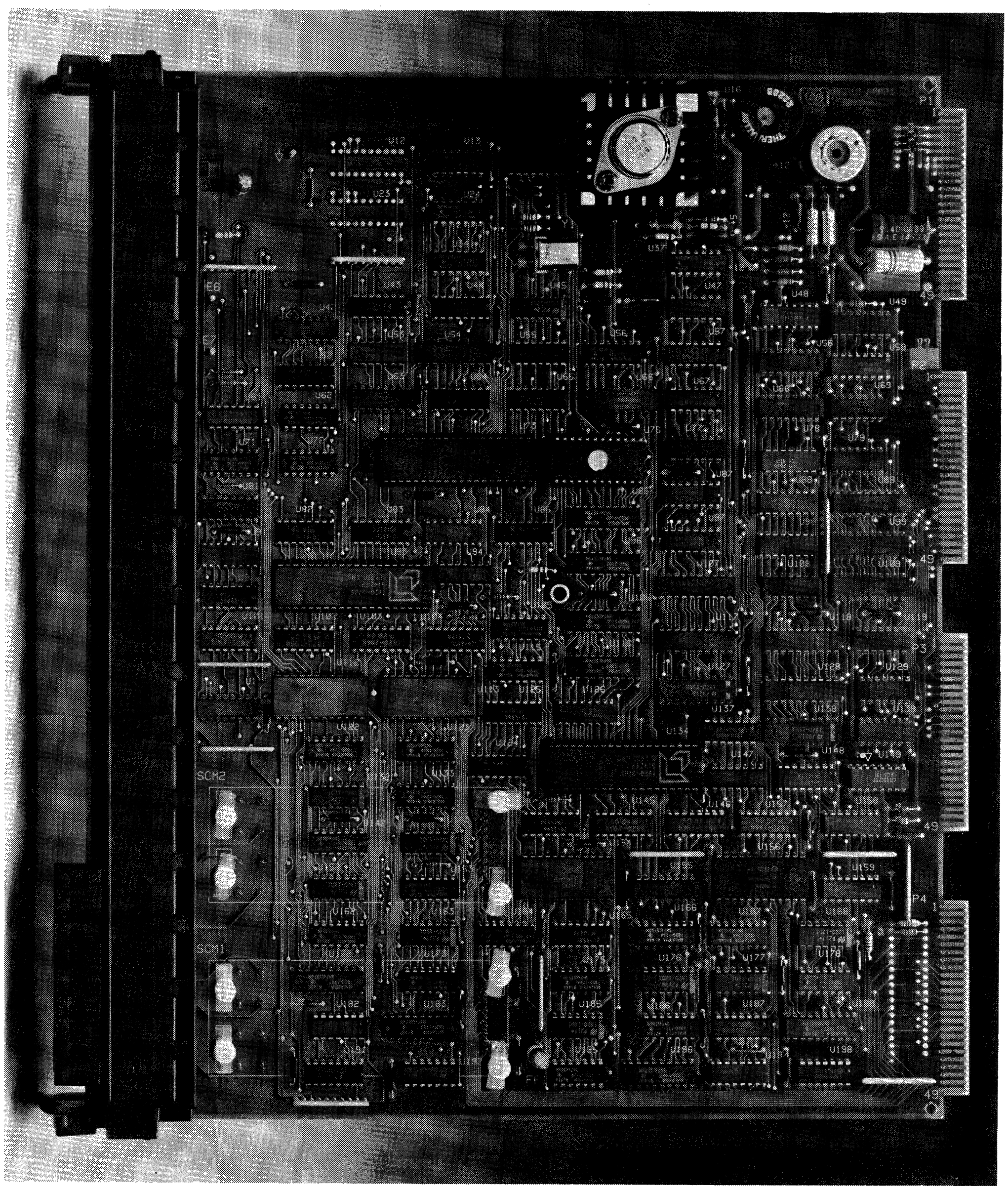

Figure 15-1. HP 25512 Counter Input Card

Unless otherwise stated, all data written to or read from the counter card is in 16-bit unsigned integer format. Note that this is different from the HP 2250's 16-bit two's complement data format for values greater than 32767. Your host computer may need to deal with these numbers in double precision format to make use of their full range; otherwise they may appear to be 16-bit two's complement numbers (numbers greater than 32767 will be treated as negative numbers).

15.3 SPECIFICATIONS

Table 15-1 gives the specifications for the HP 25512 Counter Card.

Table 15-1. HP 25512 Counter Card Specifications

FEATURES

* 4 independent input channels
* 10 counting modes, including 32 bit totalize, up-down counting, frequency, and period.
* 5 programmable interrupts per channel (20 total)

Table 15-1. HP 25512 Counter Card Specifications, continued

APPLICABLE MCL COMMANDS
CFN command : Write 2 Words of Configuration Data
ECFN command : Write 4 Words of Configuration Data
RCFN command : Read 4 Words of Configuration Data
CNUMBER command : Write Number of Counting Periods
RCNUMBER command : Read Number of Counting Periods
CCONTROL command : Write Counter Channel Control Word
COUNT command : Read 1 Word of Count Data Without Restarting Channel
DCOUNT command : Read 2 Words of Count Data Without Restarting Channel
RCOUNT command : Read 1 Word of Count Data and Restart Channel
RDCOUNT command : Read 2 Words of Count Data and Restart Channel
INTERRUPT command : Enable Interrupt Conditions
RINTERRUPT command : Read Interrupt Condition Enable Status
RCS command : Read Card Status Register Bits

Table 15-1. HP 25512 Counter Card Specifications, continued

GENERAL COUNTING MODE SPECIFICATIONS

* Frequency: 400 KHz max

  Pulse width (Tw): 1.25 uS min

  Pulse gap (Tg): 1.25 uS min

```
        +------+          +------+
        |  Tw  |    Tg    |      |
    ----+      +----------+      +-----
```

* Timing for Gated Functions:

Range value	Max. Rate	Resolution	Gate Time
1	30 Hz	0.001 Hz	1000 sec
2	300 Hz	0.01 Hz	100 sec
3	3 KHz	0.1 Hz	10 sec
4	30 KHz	1 Hz	1 sec
5	300 KHz	10 Hz	100 msec
6	400 KHz	100 Hz	10 msec

* Triggering: Controlled by the MCL/50 configuration commands to trigger off of the rise or fall of the input signal.

* Number Format:
  All functions except up-down count: unsigned integer
  Up-down count: two's complement

* Totalize: 0 to 65,535

* Totalize Rollover: to 0

* Extended Totalize: 0 to 4,294,967,295

* Extended Totalize Rollover: to 0

* Prescale: 0 to 65,535

* Up-Down: -32,768 to 32,767

* Up-Down Rollover: none (stays at -32,768 or 32,767)

Table 15-1. HP 25512 Counter Card Specifications, continued

* Period and Time Interval:

Number of periods or time intervals measured:
1 to 32,767

Accuracy: ±0.01% of reading ±1 count

Range value	Time Interval	Resolution
1	50 min	100 msec
2	5 min	10 msec
3	30 sec	1 msec
4	3 sec	100 usec
5	300 msec	10 usec
6	30 msec	1 usec

* Ratio:

Gate time: 1 to 65,535 counts of B input

Resolution: 1/Gate time

Range: 1 to 65,535 counts of A input

Accuracy: ±1 count

* Environmental: Same as HP 2250 controller section

* Power Consumption

+5 volt supply : 835 mA / 4.18 Watts
+12 volt supply : 15.26mA / 0.18 Watts
-12 volt supply currently not used

* Diagnostic Output

High Level output voltage : 2.7 volts min.
Low Level output voltage : 0.4 volts max.
High Level output current : 400 uA max.
Low Level output current : 8 mA max.

Table 15-1. HP 25512 Counter Card Specifications, continued

PROGRAMMING PERFORMANCE SPECIFICATIONS
Minimum I/O Command Response Time : .3 msec
Maximum I/O Command Response Time : 2.7 msec
PHYSICAL CHARACTERISTICS
Width : 34.8 cm (13.54 inches)
Depth : 28.91 cm (11.38 inches)
Height : 3.5 cm (1.38 inches)
Weight : 680 grams (1.5 lbs)

15.4 SIGNAL CONDITIONING

The counter card may accomodate a maximum of two input signal conditioning modules (SCMs) to operate all four channels. Each SCM conditions the A and B inputs for two consecutive channels (channels 1 and 2, or channels 3 and 4) and the counter card will support a varity of SCMs. Below is a list of SCMs which the counter card supports:

25535B : 5 VDC Non-Isolated Source Input
25535C : 12 VDC Non-Isolated Source Input
25535D : 24 VDC Non-Isolated Source Input
25535E : 48 VDC Non-Isolated Source Input
25535K : 5 VDC Non-Isolated Sink Input
25535L : 12 VDC Non-Isolated Sink Input

25536B : High Speed 5 VDC Non-Isolated Source Input
25536K : High Speed 5 VDC Non-Isolated Sink Input

25537P : 5 VDC Isolated Input
25537Q : 12 VDC Isolated Input
25537R : 24 VDC / 16 VAC Isolated Input
25537S : 48 VDC Isolated Input
25537T : 72 VDC Isolated Input
25537U : 120 VDC/72 VAC Isolated Input
25537V : 115 VAC Isolated Input
25537W : 230 VAC Isolated Input

Caution must be taken when selecting a particular SCM because some of the SCMs invert the signal before it reaches the counter card. All specifications which refer to input signal edges (e.g., count up on rising edge and down on falling edge) are with respect to the input of the counter card's logic (SCM output) and not the input to the SCM. The matrix below shows how the various SCMs treat the sense of an input signal.

		Input to SCM		
		0	1	NC *
SCM type	Source	1	0	1
	Sink	0	1	1
	Isolated	1	0	1

This matrix shows the value transmitted to the counter card from the output of an SCM for a given combination of input logic level and SCM type. Source-type SCMs include HP 25535B-E and HP 25536B. Sink-type SCMs include HP 25535K,L and HP 25536K. Isolated SCMs include HP 25537P-W.

* NC = not connected

15.5 FUNCTIONAL DESCRIPTION

The functional block diagram in figure 15-2 shows the major functions of the HP 25512 counter card.

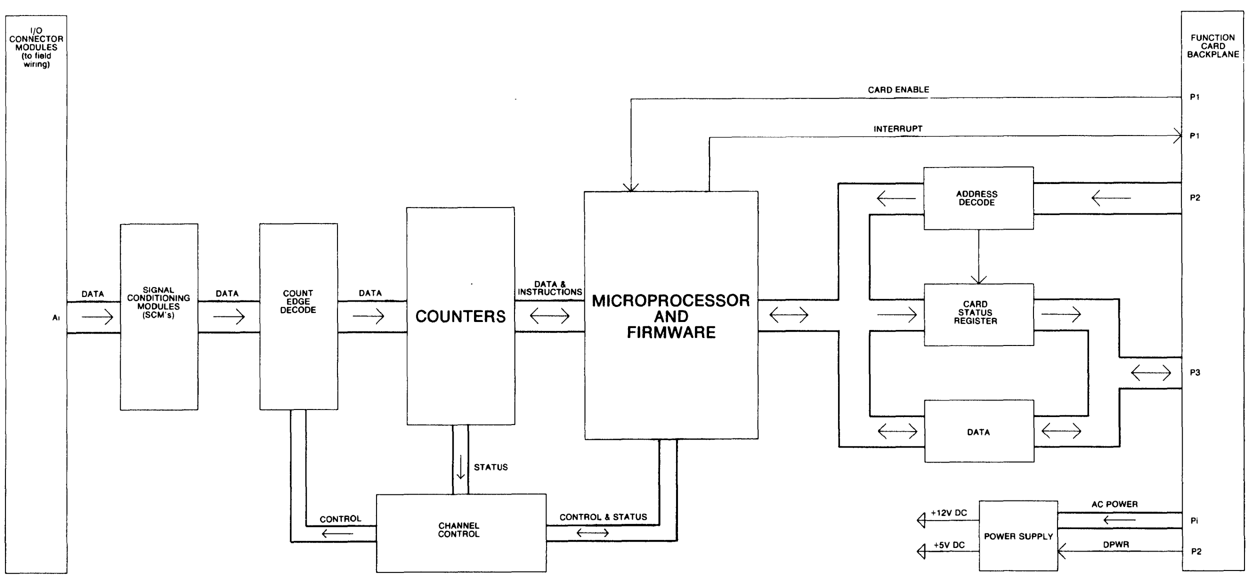

Figure 15-2. HP 25512 Counter Card Functional Block Diagram

15.5.1 CARD LOGIC

The functional sections of the counter card can be broken down into four main categories: input logic, backplane interface, microprocessor and firmware, and system timing control. These will be discussed briefly in the following paragraphs.

15.5.1.1 Input Logic

There are four input channels on the counter card, and each channel has two subchannels, A and B. The way these subchannels are used depends on the counting function for which the card is configured, as is described later in this section.

Two 4-channel signal conditioning modules (SCMs) are used on the card, one for the subchannels on channels 1 and 2, the other for the subchannels on channels 3 and 4. Thus, you can have different signal conditioning on the two pairs of channels. After the input signals pass through the SCMs, they are translated from 0-12 volt levels to the 0-5 volt (TTL) levels used on the card. The asynchronous input signals are then synchronized to a 1 mHz clock and passed to the system timing control section of the card.

15.5.1.2 Backplane interface

The backplane interface handles all of the communication handshaking and data transfers between the microprocessor and the backplane of the HP 2251 measurement and control unit (MCU). This section also performs signal translation between the card and the backplane (translation between 0-12 volt signals and 0-5 volt signals).

The backplane interface contains three registers: address, data, and card status. (Note that the card status register is the only physical register on the card; all other "registers" are memory locations in the microprocessor.) The address register specifies which function is to be performed by a given channel, by giving the start address of the appropriate section in the firmware. The data register transfers information between the backplane and the card. This may be in the form of parameters to be passed from the backplane to the firmware (to go along with the address specified in the address register), or count data to be passed from the card to the backplane. The card status register indicates whether the card is busy, which channels are correctly configured, and which channels have data available for reading.

15.5.1.3 Microprocessor and firmware

This section controls the activities on the card. It consists of a microprocessor and its associated firmware (stored in EPROM). The firmware furnishes the instructions that allow the microprocessor to execute the commands that are sent in from the backplane. The microprocessor and firmware control all communications and data transfers between the backplane interface and the card. It also sends commands to and receives data from the integrated circuits (ICs) in the system timing control section.

15.5.1.4 System timing control

The system timing control section of the card performs the actual counting. There are two system timing control ICs, and each IC handles the counting for two channels. (Note that each channel is completely independent of all other channels.) The ICs can be configured in different ways to perform the various counting functions; the configuration instructions are provided by the microprocessor. The ICs include logic to count either rising or falling edges of the input signal, according to the instructions from the microprocessor.

15.5.2 COUNTING FUNCTIONS

The 10 counting functions available on the counter card are in two categories, known as ungated and gated functions. The ungated functions count only external signals, and are not controlled by any other signal. For example, the extended totalize function is an ungated function: it counts the A input until the channel is explicitly commanded to stop counting. Valid counts are always available from active channels configured for an ungated function.

The gated functions count a signal for an interval defined by another signal. These signals may be either internal or external to the counter card. All of the gated functions actually count two signals: one is the gate signal, which determines when the count will stop, and the other is the count signal, which is the count returned when the channel is read. No valid count is available from a channel configured for a gated function until the count is complete (that is, the counting gate has closed). For example, the frequency mode function is a gated function: it counts the A input for a period of time determined by counting one of six internal clock signals.

In all cases, it is the edge transition of an input that increments or decrements a count.

15.5.3 UNGATED FUNCTIONS

The ungated functions programmable on the HP 25512 Counter Card are:

15.5.3.1 Totalize

A channel configured for totalize mode can make two counts simultaneously, one on the A inputs of the channel and one on the B inputs. In totalize mode both the A and B subchannels can count and furnish results independently. The count data read from a totalize subchannel is in 16-bit unsigned integer format. The count begins at 0 and counts up to 65535, then rolls over to 0 and continues counting up. If the subchannel has its overflow interrupt enabled, the counter card will interrupt the HP 2250 when the subchannel´s count rolls over from 65535 to 0. A channel configured for totalize mode is also configured with preset values for both subchannels: if the subchannel has its completion interrupt enabled, the counter card will interrupt the host when the count reaches the preset value.

Totalize mode is the only counting function that supports two counts per channel: all other counting modes have only one count per channel.

15.5.3.2 Extended Totalize

A channel configured for extended totalize mode counts the A input. The count data available to be read from the channel is in 32 bit unsigned format, but it must be read in two 16 bit words. The count begins at 0, counts up to 4,294,967,295 (2^32-1), and rolls over to 0. If the count rolls over, the counter card will interrupt the host if the interrupt has been enabled; in either case, the count will continue.

15.5.3.3 Prescale

A channel configured for prescale mode counts the A input down from a preset value to 0. The channel can be configured to restart the count immediately when the count reaches 0, or to stop counting until explicitly instructed to start again. When the count reaches 0, the counter card will interrupt the host if the interrupt has been enabled. There is always valid data available from a channel configured for the prescale mode, although the normal operating condition for this mode will be to wait for the count completion interrupt to occur.

15.5.3.4 Up-Down Count

A channel configured for up-down mode counts according to both the A and B inputs. The channel can be configured to count in one of three ways: (1) The count is incremented by the edges of the A input and decremented by the edges of the B input; (2) The channel counts the edges of the A input, with the direction controlled by the level of the B input; (3) The count is incremented or decremented on all edges of the A or B inputs, with the direction controlled by which edge changes state first (quadrature). In every case, the count begins at a preset value and counts up to 32767 or down to -32768. There is no rollover for an up-down count. If the count goes over 32767 or under -32768, the counter card will interrupt the host if the overflow or underflow interrupt has been enabled.

Up-down count mode is the only counting function on the counter card to return data in 16-bit two's complement format.

15.5.4 GATED FUNCTIONS

The gated functions programmable on the HP 25512 Counter Card are:

15.5.4.1 Frequency

A channel configured for frequency mode counts the A input for a period of time determined by counting one of 6 internal clock signals 10,000 times. The available clock signals are 10Hz, 100Hz, 1KHz, 10KHz, 100KHz, and 1MHz, giving frequency mode counting periods of 1000 sec, 100 sec, 10 sec, 1 sec, 100 msec and 10 msec respectively. The units of the frequency returned depend on the length of the counting period; those units can be: .001Hz, .01Hz, .1Hz, 1Hz, 10Hz, and 100Hz. The count data is available only when the counting period has completed.

Internal Clock	Counting Period	Result Units
10 Hz	1000 sec	.001 Hz
100 Hz	100 sec	.01 Hz
1K Hz	10 sec	.1 Hz
10K Hz	1 sec	1 Hz
100K Hz	100 msec	10 Hz
1M Hz	10 msec	100 Hz

The count data is in 16 bit unsigned format. The count begins at 0 and counts up to 65535, then rolls over to 0 and counts up again. When the counting period is complete, the counter card will interrupt the host if the interrupt has been enabled. If the count rolls over to 0 from 65535, the counter card will interrupt the host if the interrupt has been enabled. When the count is complete, the channel can be programmed either to begin counting again at the start of the next period, or to stop counting until instructed to start again.

15.5.4.2 Period

A channel configured for period mode counts one of 6 internal clock signals for the period defined by either the rising or falling edges of the A input. The available clock signals are 10Hz, 100Hz, 1KHz, 10KHz, 100KHz, and 1MHz; the units of the count data read from a channel configured for period mode are 100 msec, 10 msec, 1 msec, 100 usec, 10 usec or 1 usec, respectively. The count data is valid only when the counting period has completed.

Internal Clock	Result Units
10 Hz	100 msec
100 Hz	10 msec
1K Hz	1 msec
10K Hz	100 usec
100K Hz	10 usec
1M Hz	1 usec

The count data is in 16 bit unsigned format. The count begins at 0 and counts up to 65535, then rolls over to 0 and counts up again. When the counting period is complete, the counter card will interrupt the host if the interrupt has been enabled. If the count rolls over to 0 from 65535, the counter card will interrupt the host if the interrupt has been enabled. When the count is complete, the channel can be programmed to either begin counting again at the start of the next period, or to stop counting until instructed to start again.

15.5.4.3 Period Average

A channel configured for the period average mode operates exactly the same as for the period function, except the internal clock signal is counted for a programmable number of the input periods instead of for just one. (The result reported is the total number of counts; you have to divide by the number of periods to get the period average.)

15.5.4.4 Time Interval

A channel configured for the time interval mode operates exactly the same as for the period mode, except the time period being counted is controlled by some other programmable combination of the edges of the A and B inputs (e.g, from the rising edge of A to falling edge of B).

15.5.4.5 Time Interval Average

A channel configured for the time interval average mode operates exactly the same as for the time interval mode, except the internal clock signal is counted for a programmable number of the input periods instead of for just one. (The result reported is the total number of counts; you have to divide by the number of time intervals to get the time interval average.)

15.5.4.6 Ratio

A channel configured for the ratio mode counts the A input for a programmable number of counts of the B input. The count data is valid only when the counting period is complete. The count starts at 0 and counts up to 65535, then rolls over to 0 and counts up again. When the counting period is complete, the counter card will interrupt the host if the interrupt has been enabled. If the count rolls over from 65535 to 0, the counter card will interrupt the host if the interrupt has been enabled.

Note that it actually takes (preset + 1) B edges to complete a ratio count. The ratio count starts when the first B edge is detected, and completes after an additional preset number of edges have been counted.

15.5.5 INTERRUPTS

The counter card is able to generate interrupts on certain conditions:

completion of count on any (sub)channel
overflow of count on any (sub)channel
underflow of count on any channel

A given interrupt is enabled by unmasking the appropriate bit in the INTERRUPT ENABLE register. When the condition occurs, the corresponding bit is set in the INTERRUPT register.

Further details on interrupts can be found in the paragraphs on register assignments later in this section, and in the HP 2250 Programmer's Manual.

15.5.6 DIAGNOSTICS

The counter card contains loopback circuitry that allows it to test nearly all of itself when used with HP-supplied diagnostics. This testing can be done in either of two modes: internal loopback or external loopback.

Under internal loopback, the microprocessor turns off the input lines and generates internal test signals that are fed through the circuitry of the card. This mode can test all of the card except the SCMs. All of the ten counting modes can be tested, with the restriction that only one edge of the test signal (the falling edge) can trigger a count.

Under external loopback, the card provides TTL level signals at the DIAGA+ and DIAGB+ output pins on the card connector. Through the use of the appropriate test fixture, these signals can be routed back through the input pins. In this manner, the card can provide signals to test 100% of itself, including the SCMs. The only limitation is that the frequency of the test signal has an upper limit of approximately 2 kHz; any components that might be marginal at higher speeds would not be detected.

The diagnostic test procedure for the counter card is given in the HP 2250 Diagnostic and Verification Manual, part number 25595-90001.

15.6 REGISTER ASSIGNMENTS

The counter card derives the information it needs for its operation from the values written to the card registers. Table 15-2 shows the register assignments for the counter card. You can set or examine the values in the registers standard MCL/50 commands, MCL/50 register commands (READ, DREAD, WRITE, and DWRITE), or the MCLIO subroutine. (Refer to the HP 2250 Programmer's Manual and the HP 25581A Automation Library Manual for details.) Table 15-3 shows which commands affect which registers. The meanings of the values in the individual registers are given after table 15-3.

Except for the CARD STATUS register, all registers shown in table 15-2 are actually memory locations in the microprocessor. Registers not shown in table 15-2 don't exist. If you write to a non-existent register, nothing will happen. If you read from a non-existent register, the card will return a value of zero.

NOTE

If you write values directly to the registers on the control card using MCL/50 register commands or MCLIO commands, be careful that you write the values to the correct registers. If you write your values to the wrong registers you can cause the card to malfunction. Be particularly careful not to write anything to registers 209 through 224 (the DEBUG and DIAGNOSTICS registers), since those registers communicate directly with the system timing control ICs without going through the microprocessor. (Writing to those registers is an especially rapid way to mess up the card configuration.)

We recommend that you use the standard MCL/50 commands whenever possible, as those commands will address only the correct registers. If you do make a mistake and cause the card to malfunction, you can recover by issuing a RESet or SYstem Normalize command; this will reset the card (as well as the system) to its initialization values.

Table 15-2. Counter Card Register Assignments

	PAGE 1	PAGE 2	PAGE 3	PAGE 4
1	COUNT1 *			
2	COUNT2 *			
3	COUNT3 *			
4	COUNT4 *			
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

* = double word register

Table 15-2. Counter Card Register Assignments, continued

	PAGE 9	PAGE 10	PAGE 11	PAGE 12
1	COUNT1 *	NUM PERIODS1		CONTROL 1
2	COUNT2 *	NUM PERIODS2		CONTROL 2
3	COUNT3 *	NUM PERIODS3		CONTROL 3
4	COUNT4 *	NUM PERIODS4		CONTROL 4
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1	CONFIG 1-1 *	DEBUG	INTER ENABLE	INTERRUPTS
2	CONFIG 1-2 *	DEBUG	INTER ENABLE	INTERRUPTS
3	CONFIG 2-1 *	DEBUG		
4	CONFIG 2-2 *	DEBUG		
5	CONFIG 3-1 *	DEBUG		
6	CONFIG 3-1 *	DEBUG		
7	CONFIG 4-1 *	DEBUG		
8	CONFIG 4-2 *	DEBUG		
9		DEBUG		CARD CONFIG
10		DEBUG		0
11		DEBUG		CARD STATUS
12		DEBUG		0
13		DEBUG		CARD ID REG
14		DEBUG		0
15		DIAGNOSTICS		0
16		DEBUG		BIF

* = double word register

Table 15-3. Relationships of Commands and Registers

Standard MCL/50 Commands	Register Commands *	Register Names	Register Numbers
CFN, ECFN	WRITE, DWRITE, READ, DREAD, MCLIO	CONFIG (1-4)	193-200
CNUMBER, RCNUMBER	WRITE, READ MCLIO	NUM PERIODS (1-4)	145-148
CCONTROL	WRITE, READ MCLIO	CONTROL (1-4)	177-180
COUNT, DCOUNT	READ, DREAD MCLIO	COUNT (1-4) **	129-132
RCOUNT, RDCOUNT	READ, DREAD MCLIO	COUNT (1-4) **	1-4
INTERRUPT, RINTERRUPT	WRITE, READ MCLIO	INTER ENABLE (1-2)	225,226
(none)	READ, MCLIO	INTERRUPTS (1-2)	241,242
RCS	READ, MCLIO	CARD STATUS	251

* We recommend that you use standard MCL/50 commands whenever possible. If you do use register commands, be careful that you are writing to the correct register; an incorrect write can cause the card to stop or to function in a way that you do not intend.

** A read from registers 1-4 returns the current value and restarts the count. A read from registers 129-132 returns the current value and does not restart the count.

The following paragraphs give the appropriate values for the various registers and explain the meanings of the bit patterns that make up several of those values. The use of these registers is fully described in the HP 2250 Programmer's Reference Manual.

15.6.1 CONFIG (R193-200)

There are two sequential register addresses used to configure each counter card channel. These are all double word registers.

Register Address	Channel Configuration
193	channel 1 first configuration register
194	channel 1 second configuration register
195	channel 2 first configuration register
196	channel 2 second configuration register
197	channel 3 first configuration register
198	channel 3 second configuration register
199	channel 4 first configuration register
200	channel 4 second configuration register

Either two or four data words must be written to these register addresses to configure a channel to count in a particular mode. The four data words to be written for configuration are the function code, preset/range, count-mode/preset, and trigger data.

15.6.1.1 Function Code

The function code indicates which of the 10 counting modes is being configured.

function code	counting function
1	totalize
2	extended totalize
3	prescale
4	up/down count
9	frequency
10	period
11	period average
12	time interval
13	time interval average
14	ratio

Any other data value is invalid. (Note that the upper byte of the function code value is ignored; so 256 gives the same result as 0, 257 gives the same result as 1, and so on.)

15.6.1.2 Preset/Range

For those counting modes which require a preset (totalize, prescale, up-down, ratio), the second data word is that preset. The preset is a 16 bit integer. For prescale and ratio modes, the preset cannot be 0 or 1. For totalize mode, the second word of data is the preset for subchannel A.

For those counting modes which use one of the internal clock signals (frequency, period, period average, time interval, time interval average), the second data word indicates which of the 6 internal clocks to select. This data word must be in the range 1 to 6.

range data	internal clock frequency
1	10Hz
2	100Hz
3	1KHz
4	10KHz
5	100KHz
6	1MHz

For the extended totalize mode, the value of the preset/range data word is meaningless.

15.6.1.3 Count-mode/Preset

For those functions which can be configured to count continuously (prescale and all of the gated functions), the third data word indicates whether to count continuously or only once. If a channel is configured with count-mode=1, it will count continuously once started; that is, the count will restart automatically as soon as the count is complete. If count-mode=0, the channel is configured to count only once, and it must be started by other means described later.

For totalize mode, the third data word is the preset for subchannel B.

For the remaining functions (extended totalize and up/down count), the third data word is meaningless.

15.6.1.4 Trigger

The fourth data word indicates which input edges are to trigger counting. The meaning of this data word varies amoung the different counting modes.

For totalize mode, the trigger data controls the counting as follows:

Trigger	Subchannel A	Subchannel B
0	count rising edges	count rising edges
1	count falling edges	count rising edges
2	count rising edges	count falling edges
3	count falling edges	count falling edges

For extended totalize, prescale, and frequency modes, a trigger data value of 0 indicates that the channel count is to be incremented by the rising edge of the A input; a trigger data value of 1 indicates that the channel count is to be incremented by the falling edge of the A input.

For the period and period average modes, trigger=0 indicates that the counting period is from the rising edge of the A input to the next rising edge of A; trigger=1 indicates that the counting interval is from the falling edge of A to the next falling edge of A.

For the up-down count mode, the trigger data word controls the counting as follows:

Up-down Trigger

0: count up on rising edge of A, down on rising edge of B
1: count up on falling edge of A, down on rising edge of B
2: count up on rising edge of A, down on falling edge of B
3: count up on falling edge of A, down on falling edge of B
4: count rising edges of A, up when B is high, down when B is low
5: count falling edges of A, up when B is high, down when B is low
6: count rising edges of A, up when B is low, down when B is high
7: count falling edges of A, up when B is low, down when B is high
8: count up when A lags B, down when A leads B
9: count up when A leads B, down when A lags B

For the time interval and time interval average modes, the trigger data word controls the counting as follows:

Trigger	Time Interval
0	rising edge of A to rising edge of B
1	falling edge of A to rising edge of B
2	rising edge of A to falling edge of B
3	falling edge of A to falling edge of B
4	rising edge of A to falling edge of A
5	falling edge of A to rising edge of A

For the ratio mode, the trigger data word controls the counting as follows:

Trigger	Ratio Counting Mode
0	rising edge of A, rising edge of B
1	falling edge of A, rising edge of B
2	rising edge of A, falling edge of B
3	falling edge of A, falling edge of B

15.6.1.5 Writing Configuration Data

When you write configuration data to the counter card CONFIG register addresses, you are actually writing to a state machine, not to registers. The state machine has certain expectations about the data that you write to it, and you must meet those expectations to get a correctly configured channel. (Since the configuration is done by a state machine and not by a set of registers, you can't change the configuration just by writing a couple of new values to some registers.)

You can configure a channel on the counter card by writing either two sequential single-word values or two sequential double-word values to the CONFIG register addresses. (If you try to write any other combination of words, the counter card will reject the configuration and set the appropriate bit in the CARD STATUS register.) If you write two sequential double-word values to the CONFIG register addresses, the words you write will be interpreted as follows:

Word Written	Meaning
1st register, word 1	function code
1st register, word 2	preset/range
2nd register, word 1	count mode
2nd register, word 2	trigger

If you write two sequential single-word values to the CONFIG register addresses, the words you write will be interpreted in this way:

Word Written	Meaning
1st register, word 1	function code
2nd register, word 1	preset/range

Thus, you can use single-word writes for those configurations that require only function code and preset/range values. Single-word writes can be made with the CFN or WRITE commands; double-word writes can be made with the ECFN or DWRITE commands.

The counter card firmware will discard the upper byte of the function code and trigger words. Thus, only the low byte of the data written for the function-code and trigger words is significant.

The two possible ways of configuring a counter card channel are implemented by the MCL commands CFN and ECFN.

```
WRITE(slot,config-reg,2) fcn-code,preset/range
```

is equivalent to

```
CFN(slot,channel#) fcn-code,preset/range
```

and

```
DWRITE(slot,config-reg,2) fcn-code,preset/range,count-mode,trigger
```

is equivalent to

```
ECFN(slot,channel#) fcn-code,preset/range,count-mode,trigger
```

If the counter card CONFIG registers are written to in any way different from these examples, the corresponding channel(s) will be incorrectly configured.

15.6.1.6 Configuration Completion

The CARD STATUS register contains 4 bits used to indicate the configuration status of the 4 channels. If the configuration bit in the CARD STATUS register is set for a particular channel, the channel is incorrectly or incompletely configured. Only if the configuration bit is clear can the channel begin counting. (The meanings and positions of these bits are described below, in the paragraphs on the CARD STATUS register.)

When any CONFIG register address is written to, the corresponding channel stops counting if it is active, and waits for the configuration to be completed. If all of the configuration data written is valid, the configuration will be completed and the CARD STATUS register configuration bit for that channel will be cleared. If any of the configuration data is not valid (e.g., undefined function code, trigger value out of range, invalid CNUMBER data), the configuration will not be completed and the channel cannot begin counting until correctly configured.

15.6.1.7 Reading Configuration Data

The data written for configuration by the ECFN and CFN commands (or their MCL/50 register and MCLIO equivalents) can be read back by the host by reading from the same register addressses that were written to by the configuration commands.

To read the configuration data, do double word reads from the 2 sequential configuration register addresses for a channel. The data returned will be the data that was written, except that the high byte of the function code and trigger data will all be 0 (the counter card firmware discards the upper byte for these data words).

Unlike writing the configuration data, there is a one-to-one correspondence between the register read and the data returned:

Register Read	Data Returned
1st register, word 1	function code
1st register, word 2	preset/range
2nd register, word 1	count-mode
2nd register, word 2	trigger

The MCL command RCFN will return these four data words.

```
DREAD(slot#,config-reg#,2)
```

is equivalent to

```
RCFN(slot#,channel#)
```

15.6.2 NUM PERIODS (R145-148)

The period average and time interval average modes require more configuration data than provided by the ECFN or CFN commands (or their MCL/50 register and MCLIO equivalents). These two modes count internal clock signals for a programmable number of periods or time intervals (see the descriptions above). The number of periods or time intervals over which the channel is to count is written as data to the following register addresses:

Register Address	Configuration
145	channel 1 number of counting intervals
146	channel 2 number of counting intervals
147	channel 3 number of counting intervals
148	channel 4 number of counting intervals

The MCL command CNUMBER is equivalent to using the WRITE command to write to these register addresses:

```
WRITE(slot#,number-reg#) number-of-intervals
```

is equivalent to

```
CNUMBER(slot#,channel#) number-of-intervals
```

The period average and time interval average modes are not completely configured until the number of intervals data has been written. This data must be written after the other configuration data has been written to the configuration register addresses. The number of intervals data cannot be 0 or 1; other than that, any 16 bit integer value is valid.

Channels correctly configured for other counting functions will become incorrectly configured if the number of intervals data is written to that channel.

A double word write to these register addresses will cause the first word of data to be used for the number-of-intervals, and the second word of data will be ignored.

The data written by the CNUMBER command may also be read by reading from the same register addresses written to by the CNUMBER command. The MCL command RCNUMBER will read this data word:

READ(slot#,number-reg#)

is equivalent to

RCNUMBER(slot#,channel#)

A double word read from this register will return a 0 in the second word.

15.6.3 CONTROL (R177-180)

A correctly configured counter card channel can be started, stopped, and continued after stopping. All of these control capabilities are programmed by writing to the following counter card register addresses:

Register Addresses	Control
177	channel 1 control
178	channel 2 control
179	channel 3 control
180	channel 4 control

The MCL command CCONTROL is equivalent to using the WRITE command at these register addresses:

WRITE(slot#,control-reg#) control-data

is equivalent to

CCONTROL(slot#,channel#) control-data

For functions other than totalize, the control data is as follows:

Control Data	Effect
0	Stop active channel
1	Start correctly configured channel
2	Continue channel previously stopped

For totalize mode, the control data is as follows:

Control Data	Effect
0	Stop subchannel A
1	Start subchannel A
2	Continue subchannel A
3	unused
4	Stop subchannel B
5	Start subchannel B
6	Continue subchannel B

Only the low byte of the data word is used by the counter card. Any value in the low byte of data, other than those listed above, is ignored.

15.6.3.1 Stop Active Channel/Subchannel

Stopping an active channel or totalize subchannel will suspend the counting on that channel or subchannel. For the ungated function (totalize, extended totalize, prescale and up-down count), the counting can be resumed by continuing the count (see below). A channel configured for a gated function cannot be continued. Stopping a channel that is not active, or that is not correctly configured will have no effect.

15.6.3.2 Start Channel

Starting a channel or totalize subchannel will cause the counting to begin. If the channel or totalize subchannel is already active, it will be stopped and re-started. For the ungated functions, any previous data will be lost when the channel is started. For the gated functions, the last valid count data is still available to be read until the channel completes the count again. Starting an incorrectly configured channel or subchannel will have no effect.

15.6.3.3 Continue Channel

As described above, if the count on a channel or subchannel is stopped, it can be resumed or restarted by using the channel control continue command. If the channel is already active, or is incorrectly configured, the continue will have no effect. If the channel is correctly configured but has never been started, the continue will have the same effect as a start (control-data=1). If the channel is correctly configured for an ungated function but is not currently active, the continue command will cause the count to resume. If the channel is correctly configured for a gated function but is not currently active, the continue command will restart the channel.

15.6.4 COUNT (R1-4 AND R129-132)

Sometimes you will want to read the current count from a channel and not affect that channel's counting, and sometimes you will want to read the count and cause the channel to re-start without missing any counts. Both of these reading modes are supported on the counter card.

Since there are two counting modes (totalize, extended totalize) that will return two words of valid data, each channel's current count can be read as either a single word or double word value.

Thus, there are four ways to read a count from a counter card channel: single word read without re-start, double word read without re-start, single word read with re-start, and double word read with re-start.

For all four ways to read a count, if the channel is incorrectly configured, or if the channel has not been started, or if there is no data available yet from a channel executing a gated function, the count read will always be 0.

15.6.4.1 Single Word Read Without Re-start

Reading from the following register addresses will read the current count from a channel without affecting the channel's counting:

Register Address	Channel
129	channel 1
130	channel 2
131	channel 3
132	channel 4

The MCL command COUNT is equivalent to using the READ command to read the current count without re-starting the counter:

READ(slot#,read-reg#)

is equivalent to

COUNT(slot#,channel#)

For a channel configured for a gated function, the count returned will be the last count completed. If the channel is configured to count continuously (count-mode=1), reading the count without re-start will be the usual way to read the current count. When the count data is read from a channel executing a gated function, the channel's new data available bit in the CARD STATUS register is cleared. Thus, the data available bit indicates whether there is new, unexamined data available.

For a channel configured for totalize mode, the data returned for a single word read without restart will be the current count on subchannel A.

For a channel configured for extended totalize mode, the data returned for a single word read will be the low 16 bits of the current count.

The data returned from a read without restart from a channel configured for totalize or up-down count modes will be at most 3 milliseconds old. For the other ungated counting modes (extended totalize, prescale) the data returned will be current.

Note that the data read from a channel executing the prescale function in count continuous mode will never be 0, since the channel automatically reloads the preset value and restarts counting after completing the previous count.

15.6.4.2 Double Word Read Without Re-start

Reading two words of current count data without affecting the counter is done by doing a double word read from the same registers as the COUNT command (described above). The MCL command DCOUNT is equivalent to using the DREAD command to read the double word data:

```
DREAD(slot#,count-reg#)
```

is equivalent to

```
DCOUNT(slot#,channel#)
```

For a channel configured in totalize mode, the first word of data returned will be the count for subchannel A; the second word will be the count for subchannel B. For a channel counting in the extended totalize mode, the data returned will be the two 16 bit words described earlier. For a channel configured for any other function, the first word of data will be the same as for the COUNT command described above, and the second word of data will be 0.

15.6.4.3 Single Word Read With Re-start

Reading from the following register addresses will read a channel's current count and re-start the counter without losing any counts:

Register Addresses	Channel
1	channel 1
2	channel 2
3	channel 3
4	channel 4

The MCL command RCOUNT is equivalent to using the READ command to read the count data and re-start the count:

READ(slot#,read-reg#)

is equivalent to

RCOUNT(slot#,channel#)

For a gated function, the count data returned will be the last valid count. If the channel whose data is being read was actively counting when the RCOUNT (or equivalent READ) command was executed, the count is aborted and re-started, the count in progress is discarded, and the data returned is what ever is left over from the last count that was completed.

Read count with re-start is not appropriate for use with a channel that is configured to count continuously (count-mode=1), since the count is already re-started automatically when finished. Reading the count with re-start is more appropriate to use when the channel is configured to read the count only once (count-mode=0); then reading the count with re-start will cause the count to start every time it is read.

Reading the count with re-start is very useful for channels configured for ungated functions: the current count can be read and saved, and a new count begun without missing any counts.

If a channel is correctly configured but has not yet been started (by a CCONTROL command or the equivalent WRITE), reading the count with re-start will return zero but will start the count as if the appropriate CCONTROL start command had been executed.

Reading a single word of data with re-start from a channel configured for extended totalize mode will return the least significant 16 bits of the current count, and the count will be re-started; thus, the most significant 16 bits of data are lost.

Reading a single word of data with re-start from a channel configured for totalize mode will return the current count from subchannel A, and will restart the count only on subchannel A. The count on subchannel B is not read, and is not restarted.

Reading the count with restart from a channel configured for up-down count or totalize modes will return the current data, without the up to 3 millisecond lag time that the read without restart has.

Reading the count with restart from a channel configured for prescale mode will result in a several microsecond time window during which counts may be lost. This is the only counting function which may lose counts when read with restart. We suggest that you do not read with restart when using prescale mode.

15.6.4.4 Double Word Read With Re-start

Reading two words of data from a counter card channel and causing the count to re-start simultaneously is done by doing a double word read from the same register addresses as for the RCOUNT command (or equivalent READ command) described in the previous section. The MCL command RDCOUNT is equivalent to using the DREAD command to do this double word read:

DREAD(slot#,read-reg#)

is equivalent to

RDCOUNT(slot#,channel#)

For a channel configured for the extended totalize mode, the data returned will be the two 16 bit integers described earlier.

For a channel configured for totalize mode, the data returned will have the current count from subchannel A in the first word, and the current count from subchannel B in the second word. Both subchannels will be restarted when a double word read with restart is done from a totalize subchannel.

For a channel configured for any other counting mode, the data returned in the first word will be the same as described for the RCOUNT command, and the second word of data will be 0. In either case, the count will be re-started simultaneously. For a channel configured for any counting function, if the channel is not active, it will be started by a read with restart.

15.6.5 INTER ENABLE (R225,226)

There are 20 programmable interrupting conditions on the counter card: 5 for each channel. The interrupts are numbered from 1 through 32, and not all interrupts have meaning for the counter card.

Interrupt Number	Interrupt Condition
1	Channel 1 (subchannel A) count complete
2	Channel 2 (subchannel A) count complete
3	Channel 3 (subchannel A) count complete
4	Channel 4 (subchannel A) count complete
5	Channel 1 subchannel B count complete
6	Channel 2 subchannel B count complete
7	Channel 3 subchannel B count complete
8	Channel 4 subchannel B count complete
17	Channel 1 (subchannel A) count overflow
18	Channel 2 (subchannel A) count overflow
19	Channel 3 (subchannel A) count overflow
20	Channel 4 (subchannel A) count overflow
21	Channel 1 subchannel B count overflow
22	Channel 2 subchannel B count overflow
23	Channel 3 subchannel B count overflow
24	Channel 4 subchannel B count overflow
25	Channel 1 count underflow
26	Channel 2 count underflow
27	Channel 3 count underflow
28	Channel 4 count underflow

No one counter card function can cause all three types of interrupt on a channel.

Counting Function	Completion Interrupt	Overflow Interrupt	Underflow Interrupt
totalize	yes	yes	no
extended totalize	no	yes	no
prescale	yes	no	no
up-down	no	yes	yes
frequency	yes	yes	no
period	yes	yes	no
period average	yes	yes	no
time interval	yes	yes	no
time interval average	yes	yes	no
ratio	yes	yes	no

Each channel can be enabled to interrupt when the current count completes, when the count overflows, or when the count underflows.

The interrupts are enabled by writing to the counter card's INTERRRUPT ENABLE register addresses.

Register Address	Interrupts Enabled
225	enable interrupts 1 through 16
226	enable interrupts 17 through 32

If a bit in one of the INTER ENABLE registers is set, the corresponding interrupt is enabled:

Register	Bit#	Interrupt#	Interrupt Enabled
225	0	1	chan 1 (subch A) count complete
225	1	2	chan 2 (subch A) count complete
225	2	3	chan 3 (subch A) count complete
225	3	4	chan 4 (subch A) count complete
225	4	5	chan 1 subch B count complete
225	5	6	chan 2 subch B count complete
225	6	7	chan 3 subch B count complete
225	7	8	chan 4 subch B count complete
225	8	9	undefined
225	9	10	undefined
225	10	11	undefined
225	11	12	undefined
225	12	13	undefined
225	13	14	undefined
225	14	15	undefined
225	15	16	undefined
226	0	17	chan 1 (subch A) overflow
226	1	18	chan 2 (subch A) overflow
226	2	19	chan 3 (subch A) overflow
226	3	20	chan 4 (subch A) overflow
226	4	21	chan 1 subch B overflow
226	5	22	chan 2 subch B overflow
226	6	23	chan 3 subch B overflow
226	7	24	chan 4 subch B overflow
226	8	25	chan 1 underflow
226	9	26	chan 2 underflow
226	10	27	chan 3 underflow
226	11	28	chan 4 underflow
226	12	29	undefined
226	13	30	undefined
226	14	31	undefined
226	15	32	undefined

The MCL/50 register command WRITE can be used to enable counter card interrupts by writing the desired bit patterns to the counter card register addresses explained above. If the MCL/50 register command DWRITE is used to do a double word write to the INTER ENABLE register addresses, the second word of data for each of the registers will be ignored.

The MCL command INTERRUPT can be used to write to the individual bits in the two counter card INTER ENABLE register addresses. The INTERRUPT command reads the two INTER ENABLE registers, changes the bits indicated by the command parameters and writes the new register contents back to the function card.

```
INTERRUPT(slot#,start-bit[,number-bits]) bit-data1,...,bit-datan
```

The interrupt enable state can be read from the same registers written to. The low level command READ can be used to read back the contents of the INTER ENABLE registers, or the RINTERRUPT command can be used to read just certain bits from those registers:

```
RINTERRUPT(slot#,start-bit[,number-bits])
```

15.6.6 INTERRUPTS (R241,242)

When an interrupting event occurs on a counter card channel, if the interrupt was enabled through the INTER ENABLE register, then the corresponding bit in the INTERRUPT registers will be set to indicate that the interrupt has occured, and the counter card will set the backplane interrupt line high, signalling an interrupt to the BIF card.

Counter card interrupt status is read from register addresses 241 and 242. The bits in these registers correspond to the possible interrupts in the same way as for the INTER ENABLE registers. When the INTERRUPT register(s) are read, the counter card firmware automatically resets the INTERRUPT register(s) to 0. This prevents an interrupt from being reported more than once.

If the counter card is operating in an HP 2250, the HP 2250 firmware will automatically read the INTERRUPT registers from every card that can interrupt whenever any function card interrupts. Thus, in the HP 2250, it is not necessary for you to explicitly read the INTERRUPT registers. However, it is possible to bypass the HP 2250's interrupt servicing by disabling interrupts globally with the FCI command, and then reading the interrupt status information from the cards.

15.6.7 CARD STATUS (R251)

All of the counter card "registers" except the CARD STATUS register are actually memory locations in the card's microprocessor. The CARD STATUS register is a physical register on the card. The reason the CARD STATUS register is outside the microprocessor is that it is important for the host to be able to read the register even if the card is busy; thus, it must be independent of the counter card's processor.

The CARD STATUS register indicates whether the card is busy; which channels are correctly configured; and which channels have data available to be read.

Bit #	Card Status Register Meaning (when set)
0	data available from channel 1
1	data available from channel 2
2	data available from channel 3
3	data available from channel 4
4	channel 1 incorrectly/incompletely configured
5	channel 2 incorrectly/incompletely configured
6	channel 3 incorrectly/incompletely configured
7	channel 4 incorrectly/incompletely configured
8	undefined
9	undefined
10	undefined
11	undefined
12	undefined
13	undefined
14	undefined
15	card busy

For a channel configured for totalize mode, the data available status register bit for that channel will be set when either subchannel is started.

The CARD STATUS register can be read from register address 251. The MCL command RCS can be used to read the individual bits from the CARD STATUS register. This command reads the 16 bit contents of the CARD STATUS register from the card and extracts just the bits requested by the command parameters:

```
RCS(slot#,start-bit[,number-bits])
```

15.7 PIN ASSIGNMENTS AND CABLING

There is one card connector (connector A1) on the counter card. Table 15-4 shows the signals that are routed to the connector pins. The connector numbering scheme is shown in figure 3-11, at the end of Section III of this manual.

Table 15-4. HP 25512 I/O Connector Module Pin Assignments

CONNECTOR	PIN	CONNECTION
A1J1	1	Diagnostic A +
A1J1	2	not used
A1J1	3	Diagnostic B +
A1J1	4	card ground
A1J2	1	Channel 1 A +
A1J2	2	Channel 1 A -
A1J2	3	Channel 1 B +
A1J2	4	Channel 1 B -
A1J5	1	Channel 2 A +
A1J5	2	Channel 2 A -
A1J5	3	Channel 2 B +
A1J5	4	Channel 2 B -
A1J6	1	Channel 3 A +
A1J6	2	Channel 3 A -
A1J6	3	Channel 3 B +
A1J6	4	Channel 3 B -
A1J9	1	Channel 4 A +
A1J9	2	Channel 4 A -
A1J9	3	Channel 4 B +
A1J9	4	Channel 4 B -

The connection between the counter card and the field wiring is made with one of two field wiring assemblies (FWAs):

HP 25550A (digital card FWA with screw terminations)

25550-60003 (digital card FWA, unterminated)

Note that the HP 25550A has two sets of card connectors and cables, but that only one set is used with the counter card.

Section XVI
HP 25515 4-Channel Pulse Output

16.1 INTRODUCTION

This section provides information for the HP 25515 Pulse Output Card. Included are specifications and a functional description. Installation information for the card is provided in the HP 225 Installation and Start-Up Manual, part number 02250-90012.

16.2 DESCRIPTION

The HP 25515 Pulse Output Card, shown in figure 16-1, generates square wave pulse output on four channels, at rates up to 10,000 pulses per second. Pulses may be output either continuously ("frequency generation mode") or as a fixed-length train of pulses ("pulse generation mode"). Signal conditioning modules, described below, allow a variety of output voltage levels. Pulse outputs are provided in formats suitable for direct connection to stepper motor translators. In addition, inputs on each channel allow the connection of external signals that can be used to stop the output of pulses.

<u>I/O signals</u>. Each channel has two output lines and two input lines. The output lines, labeled A and B, can be configured for one of the two formats commonly used by stepper motor translators:

1) all pulses on line A and direction on line B, or

2) pulses for one direction on line A and pulses for the other direction on line B

where direction refers to the direction of rotation of the stepper motor, clockwise or counter-clockwise.

The two input lines of each channel are limit inputs, one for clockwise pulses and one for counter-clockwise pulses. When the limit for a particular direction is asserted, the output pulses for that direction stop. The input lines can be connected to limit switches and used to stop a stepper motor before it reaches the end of its travel.

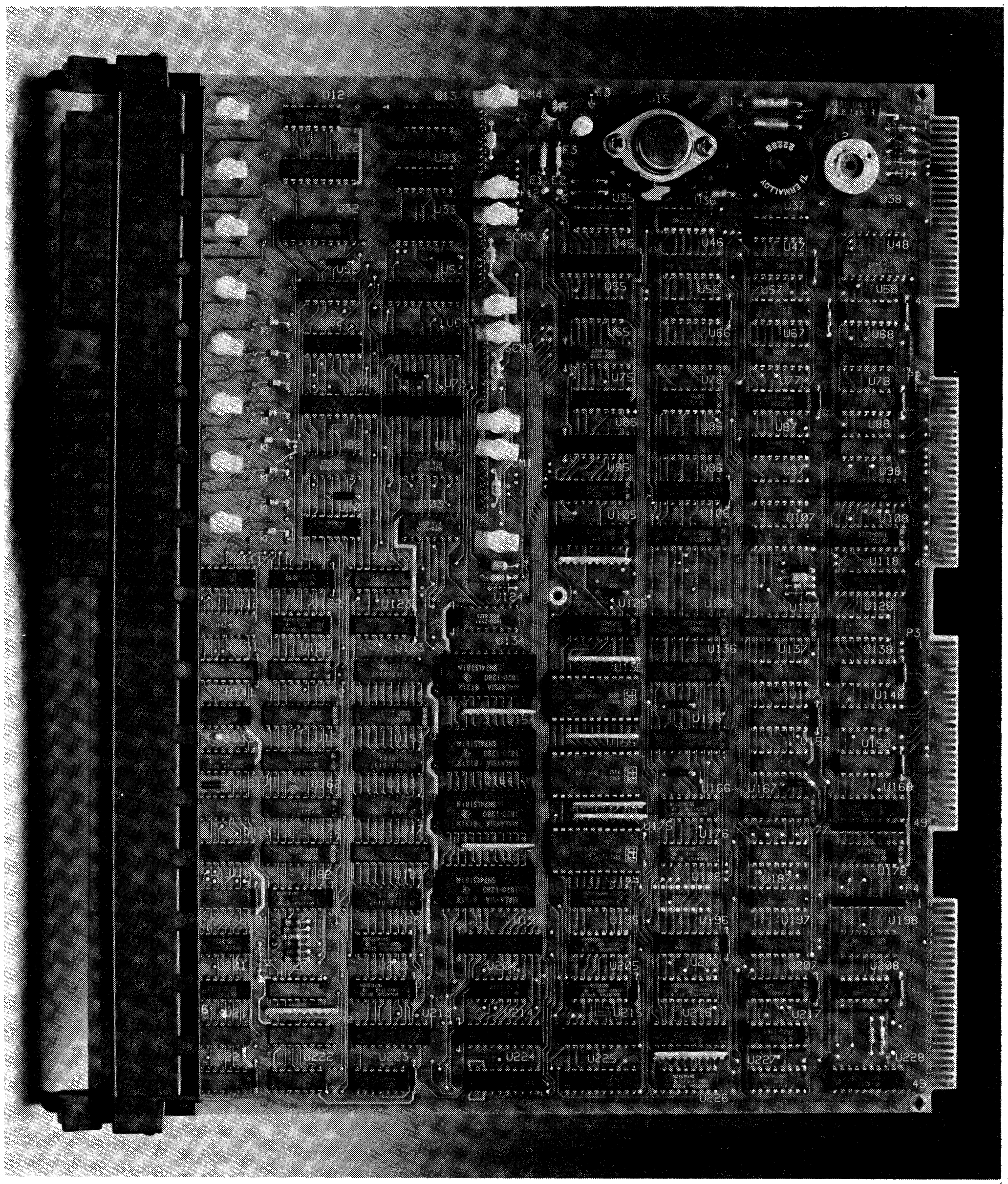

Figure 16-1. HP 25515 Pulse Card

The sense (polarity) of the output pulses and the input limit signals can be controlled by the software. Refer to the Programmer's Manual for details.

<u>Output modes</u>. Each channel of the pulse card can output pulses in two modes: frequency generation mode and pulse generation mode. In frequency generation mode, the pulse card generates a continuous stream of pulses at the same rate. This pulse stream is started by a standard MCL/50 command; it goes on indefinitely until it is stopped by another command or by limit inputs on the input lines. You need specify only the minimum pulse rate and the width of the pulses to define the pulse stream in frequency generation mode, and you can vary those parameters while the pulse stream is in progress. The Programmer's Manual describes the commands you use in frequency generation mode.

In pulse generation mode, the pulse card generates a pulse train of predetermined length and profile. (See figure 16-2.) The pulse train starts at a minimum pulse rate and accelerates until it reaches a maximim pulse rate. It continues at the maximum rate for a time, then decelerates to the minimum rate and stops. You specify the minimum rate, maximum rate, acceleration, pulse width, and total number of pulses in the pulse train. (The standard MCL/50 commands that specify these parameters are described in the Programmer's Manual.)

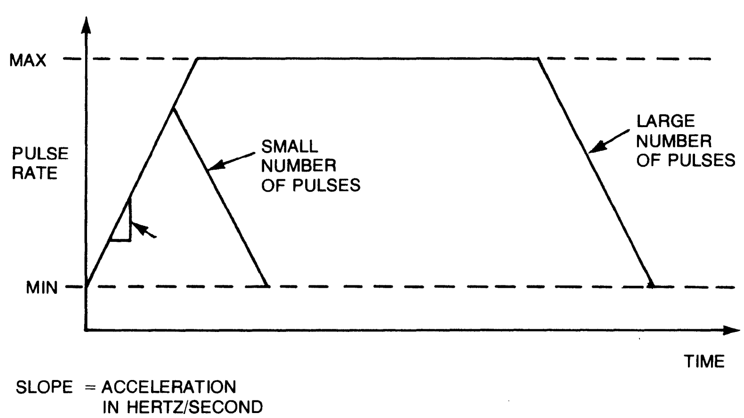

Figure 7-2: Pulse Rate vs. Time Profile in Pulse Generation Mode

After the pulse train decelerates to the minimum pulse rate, the pulse card outputs four or five more pulses at the minimum rate before stopping. These extra pulses are referred to as the "trailing plateau". The trailing plateau contains four pulses if the pulses are clockwise in direction, five pulses if counter-clockwise. Note that the first pulse at the minimum rate is part of the deceleration of the pulse train; that pulse is not counted as part of the trailing plateau.

The deceleration rate of the pulse train is the same as the acceleration rate that you specify when you define the pulse train. The pulse card calculates the starting point of the deceleration so that the total number of pulses in the entire pulse train (including the trailing plateau) is the same as the number that you specify. If half the number of pulses have been generated before the maximum rate is attained, deceleration starts immediately. (As with a pulse train that reaches the maximium rate, there is a trailing plateau of four or five pulses.)

Pulse generation mode is started with a standard MCL/50 command. It can stop in one of four ways:

1) The pulse train can complete normally.

2) A limit input can stop the pulse train.

3) An MCL/50 command can abort the pulse train immediately.

4) An MCL/50 command can cause the pulse rate to decelerate to the minimum rate and stop (without any trailing plateau).

<u>Pulse parameters</u>. The pulse parameters that define a stream of pulses (in either frequency generation mode or pulse generation mode) are:

MINRATE. In frequency generation mode, this specifies the pulse rate. In pulse generation mode, this specifies the minimum pulse rate (the starting and ending rate) for the pulse train. MINRATE is in units of 0.5 pulses per second -- that is, the actual pulse rate is MINRATE * 0.5 pulses per second. In pulse generation mode, MINRATE must be a positive integer between 0 and 19999; in frequency generation mode, MINRATE must be between 0 and 20000.

MAXRATE. In pulse generation mode, this is the maximum pulse rate that the pulse train can attain. The scaling and constraints are the same as for MINRATE. MAXRATE must be greater than or equal to MINRATE.

MAXRATE has no meaning in frequency generation mode.

ACCEL. In pulse generation mode, this specifies the rate at which the pulse train will accelerate from MINRATE to MAXRATE. The actual acceleration rate is linear, and is set equal to ACCEL *(625/32). ACCEL must be an integer between 1 and 32767. Acceleration is in units of pulses per second per second.

ACCEL has no meaning in frequency generation mode.

WIDTH. This sets the width of the pulses. Pulse widths are in units of 50 microseconds, and the actual pulse width is equal to WIDTH * 50 microseconds. WIDTH must be an integer between 0 and 32767. Some additional restrictions on pulse width are discussed in the next few paragraphs.

NUMBER of pulses. In pulse generation mode, this gives the total number of pulses in the pulse train and the direction of the pulses (clockwise or counter-clockwise). This value must be an integer between -32768 and 32767, excluding 0. If NUMBER is positive, the pulses are clockwise; if NUMBER is negative, the pulses are counter-clockwise. The number of pulses in the pulse train is equal to the absolute value of NUMBER.

In frequency generation mode, only the sign of NUMBER has significance.

(Full details on these parameters, and others, are given in the Programmer´s Manual.)

Note that a number of limitations apply to the parameters listed above. These are:

1) The pulse card is designed so that pulses can be triggered only on 100-microsecond boundaries. Thus, actual pulse periods are always multiples of 100 microseconds.

2) If you desire a pulse period that is not a multiple of 100 microseconds, the pulse card mixes pulses of different periods (in multiples of 100 microseconds) to produce a pulse train that <u>averages</u> the desired period. For instance, if you request a pulse train with a period of 160 microseconds, the pulse card will mix 100-microsecond and 200-microsecond pulse periods so that the average pulse period equals 160 microseconds.

3) To guarantee proper pulse transitions, the pulse width must always be at least 50 microseconds less than the minimum

pulse period. Note that this can have some subtle effects, due to the pulse width averaging explained in the previous item. For example, if you had requested pulses with a 160-microsecond period, you might assume that you could use a pulse width of 100 microseconds (the largest multiple of 50 microseconds that is at least 50 microseconds less than the pulse period). This would not work, however, since the pulse card would mix 100-microsecond and 200-microsecond pulse periods to average 160 microseconds, and a pulse width of 100 microseconds would be too wide for a 100-microsecond pulse period. Thus, you would have to use a pulse width of 50 microseconds with pulse periods that averaged 160 microseconds.

4) It is possible to specify pulse parameters that are outside the acceptable ranges listed above, or that violate the limitations listed here, and still get the pulse card to output a stream of pulses. Don't do it. Such a pulse stream is not reliable, and you can't be sure of what you're getting. Make sure that your pulse parameters are within acceptable ranges.

16.3 SPECIFICATIONS

Table 16-1 gives the specifications of the HP 25515 Pulse Card.

Table 16-1. HP 25515 Pulse Card Specifications

FEATURES

- Square wave output on four independent channels
- Each channel programmed independently
- Continuous output or pre-defined pulse train
- Outputs for stepper motor translators
- Frequency ramping for stepper motor control
- Limit switch inputs

APPLICATIONS

Provides pulse output for control of stepper motor translators, set point controllers, and so on.

PROGRAMMING INFORMATION

- POC command: Configure channel for pulses
- PRATE command: Set pulse rate
- PNUMBER command: Set number of pulses
- PCONTROL command: Start or stop pulse train
- INTERRUPT command: Specify function card interrupts
- RREM command: Read number of pulses remaining
- RCS command: Read card status
- RINTERRUPT command: Read interrupt mask

Table 16-1. HP 25515 Pulse Card Specifications, continued

PULSE CHARACTERISTICS
Initial or final pulse rate: 0 to 9999.5 pulses/second in pulse generation mode 0 to 10000 pulses/second in frequency generation mode
Pulse period resolution: 100 microseconds
Pulse rate resolution: 0.5 pulses/sec
Acceleration rate: 0 to approx. 640,000 pulses/sec/sec
Acceleration resolution: approx. 20 pulses/sec/sec
Number of pulses: 1 to 32767, or continuous pulse train
Pulse width: 50 to 1,638,350 microseconds
Pulse width resolution: 50 microseconds
Accuracy (MCI clock): 0.01%
PHYSICAL CHARACTERISTICS
Width: 34.8 cm (13.54 in.)
Depth: 28.91 cm (11.38 in.)
Height: 3.5 cm (1.38 in.)
Weight: 680 grams (1.5 lb.)

16.4 SIGNAL CONDITIONING

16.4.1 OUTPUT SCMS

Each pair of channels on the pulse card requires a 4-channel digital output signal conditioning module (SCM). This may be any of the standard 4-channel digital output SCMs (HP 25543-, 25544-, or 25546-series). Note, however, that the fast switching speeds of the FETs in many of these SCMs can cause transmission line ringing. We recommend, therefore, that you use the following SCMs with the pulse card whenever possible:

HP 25544A (open drain, non-isolated output)
HP 25546A (5 volt dc, buffered, non-isolated output)

The HP 25544A can accept a termination resistor to suppress ringing and still operate at full speed, and the buffering of the HP 25546A eliminates the ringing problem.

Refer to the Hardware Reference Manual for full details on the SCMs.

16.4.2 INPUT SCMS

The pulse card requires two 4-channel input SCMs for the limit inputs. These may be any of the standard 4-channel digital input SCMs.

We particularly recommend the following commonly used SCMs:

HP 25535B (5 Vdc, non-isolated source input)
HP 25535C (12 Vdc, non-isolated source input)
HP 25535L (12 Vdc, non-isolated sink input)
HP 25537P (5 Vdc, isolated input)
HP 25537Q (12 Vdc, isolated input)

Refer to the Hardware Reference Manual for more information on digital input SCMs.

16.5 FUNCTIONAL DESCRIPTION

Figure 16-3 shows a functional block diagram of the HP 25515 Pulse Card.

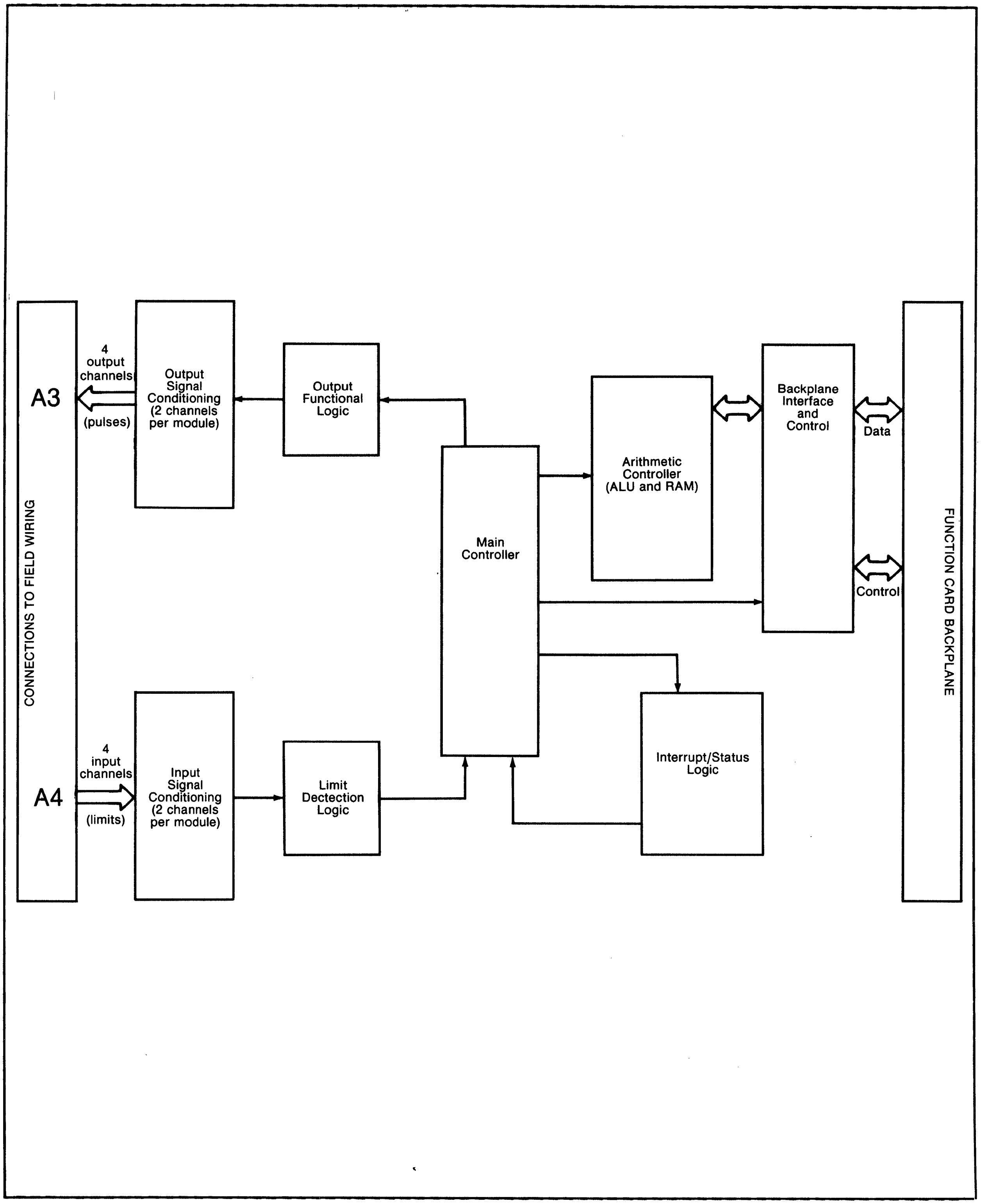

Figure 16-3. HP 25515 Functional Block Diagram

16.5.1 MAIN CONTROLLER

The main controller of the pulse card contains the counters and logic for executing the microinstruction set, which is stored in ROM. The controller steps through a 100-state loop, controlled by a 1 mHz clock. (This gives the pulse card its fundamental 100-microsecond pulse interval.) In each state it executes a 24-bit microinstruction that controls data flow, arithmetic operations, addressing, or a similar function.

The main controller carries out two principal functions:

1) servicing backplane requests. This involves transferring data between the backplane and card (on-board) RAM, in either direction.

2) controlling the pulse train. This includes controlling the rate and width of the pulses on each of the four channels of the card.

16.5.2 ARITHMETIC CONTROLLER

The arithmetic controller of the pulse card contains an arithmetic logic unit (ALU) for performing arithmetic functions, and 128 words of RAM. Each word of RAM is a 16-bit register; taken together, these registers are addressable as registers 129 through 256 of the pulse card. These registers are used to store user-assigned parameter values, as well as constants and temporary variables used by the state machine. The register map later in this chapter describes the registers that are available for your use.

The contents of RAM are loaded from ROM following each SYstem Normalize or RESet command or card power-up. As soon as RAM is initialized, the main state machine begins executing. Note that some of the values that are initialized in RAM are constants used by the main state machine. If you overwrite any of these values using MCL/50 register (WRITE) commands or MCLIO commands, the pulse card may give you unexpected results or no results at all. You can recover from this situation by issuing a SYN or RES command, or by turning off the power to the card and turning it on again.

16.5.3 OUTPUT LOGIC

There are two output lines (A and B) for each of the four channels of the pulse card. You specify, using standard MCL/50 configuration commands, the format of the pulses output on the two lines and the sense of those pulses. The logic in the output section of the card reads the configuration information from RAM and acts on the pulses accordingly.

There is also timing circuitry in the output section that controls the pulse width at 50-microsecond intervals. Since the main state machine can only control the pulse state every 100 microseconds, an external 50-microsecond timer is included in the output section to double this reslolution. The main state controller outputs the pulse state every 100 microseconds, along with an instruction that tells whether or not to change the pulse state after 50 microseconds. The timing circuitry decodes these instructions and outputs the appropriate pulses.

All output lines (A and B for each channel) pass through final output latches. These lines are synchronized with the 1 mHz clock that controls the main state machine, and pulses for all channels are output synchronously. (It is possible to synchronize the pulses on multiple cards by turning off the immediate execute (IEX) signal before the pulse you set up the pulse trains and then executing them all at the same time with a trigger to the execute (XCUT) line.)

Output pulses pass through signal conditioning modules (SCMs). All SCMs that are compatible with the pulse card are 4-point SCMs; thus, they will condition the output lines for two channels. Channels 1 and 2 are controlled by one SCM, channels 3 and 4 by another. Note that the output SCMs invert the sense of the pulses. In this manual, all descriptions of output pulse sense assume that SCMs are in place on the card and that the pulses are being read at the outputs of the SCMs.

16.5.4 INPUT LOGIC

Each of the four channels on the pulse card has two input lines. These lines are used as limit inputs; one line controls pulses in the clockwise direction and the other controls pulses in the counter-clockwise direction. When an input limit goes true, all pulses in that direction are stopped immediately.

Limit input signals come into the pulse card through two four-channel SCMs. One SCM covers the input lines for channels 1 and 2; the other SCM covers channels 3 and 4. The card is designed so that, in the default state, low or unconnected inputs yield false limits.

Each channel can be configured so that the sense of the limits on that channel is inverted (that is, so that low inputs yield true limits and high inputs yield false limits). You can do this using standard MCL/50 commands; the configuration information is stored in the channel configuration registers in RAM.

Once every 100 microseconds the main state machine reads the state of each limit input and checks the configuration register to see whether the sense is to be inverted. If the resulting limit is true, the pulse train for that direction and that channel is stopped.

16.5.5 INTERRUPT AND STATUS LOGIC

Each channel of the pulse card can generate an interrupt on one of two conditions:

1) normal completion of the pulse train

2) termination of the pulse train by limit input signal

Note that, for interrupt purposes, the use of an MCL/50 command to abort or prematurely decelerate a pulse train is considered to be normal completion.

There are eight possible interrupts that can be generated by a pulse card (2 conditions per channel times 4 channels). Interrupts are enabled by using a high level command to set appropriate bits in the INTERRUPT ENABLE register. The main state machine checks for interrupts once every 100 microseconds; if one of the interrupt conditions occurs and that interrupt is enabled, the corresponding bit in the INTERRUPT register is set. (The paragraphs below on "Register Assignments" describe the registers and the meanings of the bits in the registers.)

Interrupts collect in the INTERRUPT register until that register is read; after it is read the INTERRUPT register is cleared. The INTERRUPT register can be read by an explicit command from the user or implicitly by the system if function card interrupts are enabled (by the FCI command).

The output status of the pulse card is shown by bit settings in the STATUS register. For each channel, the STATUS register can show up to two conditions:

1) a pulse train is in progress on that channel

2) the channel is waiting for a strobe signal

The meanings of the bits in the STATUS register are described in the paragraphs on "Register Assignments", below.

16.6 REGISTER ASSIGNMENTS

The pulse card derives the information it needs from the values stored in the card registers. Each register holds one 16-bit integer word. Table 16-2 shows the register assignments for the pulse card. You can set or examine the values in the registers using standard MCL/50 commands, MCL/50 register commands (READ and WRITE), or MCLIO commands. (Refer to the Programmer's Manual and the Automation Library Manual for details.) Table 16-3 shows which commands affect which registers. The meanings of the values in the individual registers are given after table 16-3.

Table 16-2 shows only "external" registers, the ones that you will generally use in programming the card. In addition, there are several "internal" registers that are not shown; these registers are used by the card as scratch areas for storing intermediate values. You can directly address any of the registers on the card using MCL/50 register commands (READ and WRITE) or MCLIO commands. Be careful when you write to the registers on the card, for the reasons given in the following cautionary note.

NOTE

> DO NOT write to registers that are not listed in table 16-2. Writing to unlisted registers can disturb the values stored there and can cause the pulse card to malfunction. Similarly, DO NOT write improper values to the listed registers, as improper values can also cause the card to malfunction. (Appropriate values for the listed registers are given after table 16-3.) We recommend that you use standard MCL/50 commands whenever possible, as those commands will address only the correct registers. If you do make a mistake and cause the card to malfunction, you can recover by issuing a system reset command; this will reset the card (as well as the system) and cause the initialization values to be read from ROM storage into the registers.

Table 16-2. Pulse Output Card Register Assignments

	PAGE 1	PAGE 2	PAGE 3	PAGE 4
1 2 3 4 5 6 7 8				
9 10 11 12 13 14 15 16				

	PAGE 5	PAGE 6	PAGE 7	PAGE 8
1 2 3 4 5 6 7 8				
9 10 11 12 13 14 15 16				

Table 16-2. Pulse Output Card Register Assignments, Continued

	PAGE 9	PAGE 10	PAGE 11	PAGE 12
1	NUM PULSES 1	REM PULSES 1	LIMIT MIRROR	
2	NUM PULSES 2	REM PULSES 2		
3	NUM PULSES 3	REM PULSES 3		
4	NUM PULSES 4	REM PULSES 4		
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

	PAGE 13	PAGE 14	PAGE 15	PAGE 16
1	MINRATE 1	CONTROL 1	INTER ENABLE	INTERRUPTS
2	MAXRATE 1	CONTROL 2		
3	ACCEL 1	CONTROL 3		
4	WIDTH 1	CONTROL 4		
5	MINRATE 2			
6	MAXRATE 2			
7	ACCEL 2			
8	WIDTH 2			
9	MINRATE 3		CONFIGURE 1	
10	MAXRATE 3		CONFIGURE 2	
11	ACCEL 3		CONFIGURE 3	CARD STATUS
12	WIDTH 3		CONFIGURE 4	
13	MINRATE 4			CARD ID
14	MAXRATE 4			
15	ACCEL 4			
16	WIDTH 4			BIF

Table 16-3. Relationships of Commands and Registers

Standard MCL/50 Command	Register Command *	Register Names	Register Numbers
POC	WRITE, READ MCLIO	CONFIGURE (1-4)	233-236
PRATE	WRITE, READ MCLIO	MINRATE (1-4) MAXRATE (1-4) ACCEL (1-4) WIDTH (1-4)	193,197,201,205 194,198,202,206 195,199,203,207 196,200,204,208
PNUMBER	WRITE, READ MCLIO	NUM PULSES (1-4)	129-132
PCONTROL	WRITE, READ MCLIO	CONTROL (1-4)	209-212
INTERRUPT	WRITE, READ MCLIO	INTER ENABLE	225
RREM	READ, MCLIO	REM PULSES (1-4)	145-148
RCS	READ, MCLIO	CARD STATUS	251
RINTERRUPT	READ, MCLIO	INTER ENABLE	225
(none)	READ, MCLIO	INTERRUPTS	241
(none)	READ, MCLIO	LIMIT MIRROR	161

* We recommend that you use standard MCL/50 commands whenever possible. If you do use register commands, be particularly careful when you write to the registers on the card. Make sure that you are writing the correct value to the correct register; an incorrect write can cause the card to stop functioning or to function in a way that you do not intend. If you find yourself in such a situation, use a system reset to restore the card (and the system) to its original state.

The following paragraphs give the appropriate values for the various registers and explain the meanings of the bit patterns that make up several of those values. Note that the pulse card has no mechanism to prevent you from supplying an inappropriate value, or to prevent you from writing to a register that is reserved for internal use by the card. Take care to write proper values to the right registers.

CONFIGURE (R233-236) -- The bits that are set in this word determine the configuration of the channel. Only four bits (bits 0 through 3) are significant; they have the following meanings:

Bit Number	Value	Meaning
0	0	Clockwise pulses appear on output line A; counter-clockwise pulses appear on line B.
	1	Pulses for both directions appear on output line A; the pulse direction is indicated on line B. (A high output state on line B indicates clockwise pulses, and a low output state indicates counter-clockwise pulses.)
1	0	Output pulses are inverted: true pulses yield low outputs. (If the channel is configured to output only pulse direction on line B, this setting does not affect line B.)
	1	Output pulses are normal: true pulses yield high outputs.
2	0	Limit inputs are inverted: a value of 0 in the LIMIT MIRROR register yields a true limit condition; a value of 1 yields a false limit condition. (Refer to the explanation of the LIMIT MIRROR register, below.)
	1	Limit inputs are normal: a value of 0 in the LIMIT MIRROR register yields a false limit condition; a value of 1 yields a true limit condition. (Refer to the explanation of the LIMIT MIRROR register, below.)
3	0	The channel is configured for pulse generation mode.
	1	The channel is configured for frequency generation mode.

The default (power-up) value of the CONFIGURE register is 4 (bit 2 set, all other bits clear).

MINRATE (R193,197,201,205) -- This determines the starting and ending pulse rate in pulse generation mode, or the continuous pulse rate in frequency generation mode. The actual pulse rate is (MINRATE * 0.5) pulses per second. In pulse generation mode MINRATE must have an integer value between 0 and 19999; in frequency generation mode MINRATE must be between 0 and 20000.

MAXRATE (R194,198,202,206) -- This determines the maximum rate that the pulse train can attain in pulse generation mode. (It has no meaning in frequency generation mode.) The scaling and constraints are the same as for MINRATE. MAXRATE must be greater than or equal to MINRATE.

ACCEL (R195,199,203,207) -- This determines the rate at which the pulse train will accelerate from MINRATE to MAXRATE in pulse generation mode. (It has no meaning in frequency generation mode.) The actual acceleration rate is linear, and is equal to (ACCEL * (625/32)) pulses per second per second. ACCEL must be an integer value between 1 and 32767. (To get an acceleration of 0, set MAXRATE equal to MINRATE.)

WIDTH (R196,200,204,208) -- This controls the width of the pulses (the duration for which they are true). Actual pulse width is (WIDTH * 50) microseconds. WIDTH must be in the range of 0 to 32767. The pulse width must be at least 50 microseconds less than the shortest pulse interval in a pulse train.

NUM PULSES (R129-132) -- This number determines the number and direction of pulses in a pulse train. NUM PULSES must be an integer value between -32768 and 32767, excluding 0. In pulse generation mode, the number of pulses in the train is equal to the absolute value of NUM PULSES. The direction of the pulses is indicated by the sign of NUM PULSES: a positive value indicates clockwise pulses and a negative value indicates counter-clockwise pulses. In frequency generation mode the sign of NUM PULSES indicates the direction; the absoulute value has no significance.

CONTROL (R209-212) -- This controls the generation of pulses for a particular channel. There are three acceptable values:

3 Start the generation of pulses.

8 Stop pulse generation immediately.

10 Decelerate the pulse train from its current rate to MINRATE, then stop pulses. (There will be no trailing plateau.)

Any other values may give unpredictable results.

Note that the channel must be explicitly stopped (control = 8 or 10) before changing modes or before starting a new train in pulse generation mode.

INTER ENABLE (R225) -- This is an interrupt mask register that controls which interrupts are generated. Only the first eight bits (bits 0 through 7) of this register are significant. When a bit is set (= 1) the corresponding interrupt is enabled; when it is cleared (= 0) that interrupt is disabled. The correspondence between the bits and the interrupts is:

Function	Channel Number	Bit Number	High Level Code	Decimal Value (Set)
Interrupt on normal	1	0	1	1
pulse train	2	1	2	2
completion (including	3	2	3	4
user abort)	4	3	4	8
Interrupt on pulse	1	4	5	16
train termination	2	5	6	32
by limit inputs	3	6	7	64
	4	7	8	128

Note that premature stopping of the pulse train using CONTROL values of 8 or 10 is treated as normal completion by the interrupt system.

The standard MCL/50 commands used for accessing the INTER ENABLE register (INTERRUPT for setting bits, RINTERRUPT for examining their values) deal in bit patterns. The analogous MCL/50 register commands (WRITE and READ) use the decimal values equivalent to those bit patterns. Refer to the Programmer's Manual for details. Note also that the RINTERRUPT command gives you the value of the interrupt mask (the INTER ENABLE register). If you need to examine the interrupts that have been generated (the INTERRUPT register), you must use a READ command or an MCLIO command.

REM PULSES (R145-148) -- This register shows the number of pulses remaining in the pulse train for a given channel. A positive number indicates that the remaining pulses are clockwise in direction, a negative number indicates counter-clockwise pulses. In frequency generation mode, only the sign of the number is significant; the magnitude is meaningless.

CARD STATUS (R251) -- This register gives the status of the card, in the following terms:

Bit	Channel	Meaning
0	1	If set, pulses are in progress
1	2	on that channel.
2	3	
3	4	
4	1	If set, pulses are waiting for
5	2	strobe on that channel.
6	3	
7	4	

Note that the standard MCL/50 command (RCS) returns information as a series of bits, whereas the MCL/50 register command (READ) returns an equivalent decimal value.

INTERRUPTS (R241) -- This register shows which interrupts have occurred on the pulse card. Eight bits are used to show the interrupt status of the four channels. A set bit (= 1) indicates that the corresponding interrupt has occurred, and a clear bit (= 0) indicates that no interrupt has occurred. The bits have the following meanings:

Bit Number	Decimal Value (Set)	Channel Number	Meaning
0	1	1	Interrupt has occurred
1	2	2	on normal pulse train
2	4	3	completion (including
3	8	4	user abort).
4	16	1	Interrupt has occurred
5	32	2	on pulse train
6	64	3	termination by limit
7	128	4	inputs.

Note that premature stopping of the pulse train using CONTROL values of 8 or 10 is treated as normal completion by the interrupt system.

When you read the value of the INTERRUPT register with a READ command, the results are returned as a decimal integer value not as a series of bits.

The INTERRUPT register is cleared after it is read. A read of the INTERRUPT register can be caused in two ways:

1) You can read it explicitly, with a READ command or an MCLIO command.

2) The system will read it automatically if function card interrupts are enabled (FCI = 1).

When a pulse train completes, the interrupt occurs on the rising edge of the last pulse. This can cause a problem in some situations. If the channel is generating very wide pulses, the interrupt can be generated and serviced before the last pulse has completed, and before the main state machine can update the CONTROL register at the completion of the pulse train. If the interrupt schedules another task that starts a new pulse train on the same channel (an action that involves writing a new instruction to the CONTROL register), the new pulse train can contain an extra pulse. You can avoid problems in this area by having the interrupt-scheduled task check the CARD STATUS register to make sure that the old pulse train has completed before the new one is started.

LIMIT MIRROR (R161) -- Bit settings in this register reflect the pulse card's perception of the state of the limit inputs at the time that the register is read. (Due to differences in SCM types, the card's perception may not match reality, as is explained below.) A set bit (= 1) indicates a true limit input; a clear bit (= 0) indicates a false limit input. The meanings of the bits are:

Bit Number	Decimal Value (Set)	Channel	Direction
0	1	1	Counter-clockwise
1	2	2	
2	4	3	
3	8	4	
4	16	1	Clockwise
5	32	2	
6	64	3	
7	128	4	

The relationship between the logic level input to the SCM from the field wiring and the value stored in the LIMIT MIRROR register varies according to the type of SCM used. The possible relationships are:

		Input to Limit SCM		
		0	1	NC *
SCM type	Source	0	1	0
	Sink	1	0	0
	Isolated	0	1	0

This matrix shows the value stored in the LIMIT MIRROR register for a given combination of input logic level and SCM type. Source-type SCMs include HP 25535B-E. Sink-type SCMs include HP 25535K,L. Isolated SCMs include HP 25537P-W.

* NC = not connected

Note that the LIMIT MIRROR register indicates the perceived state of the input lines. It does not take into account any sense inversion that may be specified by the settings of bit 2 of the CONFIGURE registers.

The MCL/50 register command (READ) will return limit input status as a decimal integer value.

16.7 PIN ASSIGNMENTS AND CABLING

There are two card connectors (A3 and A4) on the pulse card Table 16-4 shows the signals that are routed to the connecto pins. The connector numbering scheme is shown in figure 3-11, a the end of Section III of this manual.

Table 3-1. HP 25515 I/O Connector Pin Assignments

CONNECTOR	PINS	CONNECTION	CONNECTOR	PINS	CONNECTION
A3J1	1-4	not used	A4J1	1-4	not used
A3J2	1	Chan. 1 A+	A4J2	1	Ch. 1 CW+
A3J2	2	Chan. 1 A-	A4J2	2	Ch. 1 CW-
A3J2	3	Chan. 1 B+	A4J2	3	Ch. 1 CCW+
A3J2	4	Chan. 1 B-	A4J2	4	Ch. 1 CCW-
A3J5	1	Chan. 2 A+	A4J5	1	Ch. 2 CW+
A3J5	2	Chan. 2 A-	A4J5	2	Ch. 2 CW-
A3J5	3	Chan. 2 B+	A4J5	3	Ch. 2 CCW+
A3J5	4	Chan. 2 B-	A4J5	4	Ch. 2 CCW-
A3J6	1	Chan. 3 A+	A4J6	1	Ch. 3 CW+
A3J6	2	Chan. 3 A-	A4J6	2	Ch. 3 CW-
A3J6	3	Chan. 3 B+	A4J6	3	Ch. 3 CCW+
A3J6	4	Chan. 3 B-	A4J6	4	Ch. 3 CCW-
A3J9	1	Chan. 4 A+	A4J9	1	Ch. 4 CW+
A3J9	2	Chan. 4 A-	A4J9	2	Ch. 4 CW-
A3J9	3	Chan. 4 B+	A4J9	3	Ch. 4 CCW+
A3J9	4	Chan. 4 B-	A4J9	4	Ch. 4 CCW-

The A and B lines on connector A3 are output lines. Bit settings in the CONTROL registers determine what signals are output on those lines. The CW and CCW lines on connector A4 are limit input lines for limiting pulses in the clockwise and counter-clockwise directions, respectively.

The connection between the pulse card and the field wiring is mad with one of two field wiring assemblies (FWAs):

HP 25550A (digital card FWA with screw terminations)

HP 25550B (digital card FWA, unterminated)

A

B

C

M

N

O

P

A

B

C

D

G

H

I

L

M

N

O

P

R

S

T

U

W

Z

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